		Surname		Type
Group Number		Name		A
List Number		e-mail		
Student ID		Signature		

ATTENTION:Each question has only one correct answer and is worth one point. Be sure to fill in completely the circle that corresponds to your answer on the answer sheet. Use a pencil (not a pen). Only the answers on your answer sheet will be taken into account.

1. Which of the following is the unit of Power in MKS unit system?

(a) kg m/s (b) none of them (c) $\mathrm{kg\,m^2/s}$ (d) $\mathrm{kg\,m^2/s^2}$ (e) $\mathrm{kg\,m^2/s^3}$

2. Two vectors, $\vec{a} = \hat{\imath} + 2\hat{\jmath} - \hat{k}$ and $\vec{b} = \hat{\imath} + \hat{\jmath} - 2\hat{k}$ are given. What is the magnitude of $\vec{c} \cdot (\vec{a} \times \vec{b})$ if $\vec{c} = 2\vec{a} - 3\vec{b}$ is given as a new vector?

(a) $\sqrt{35}$ (b) 0 (c) $\sqrt{29}$ (d) 5 (e) 6

3. The two non-zero vectors $\vec{a}$ and $\vec{b}$ satisfy the equation $|\vec{a} + \vec{b}| = |\vec{a} - \vec{b}|$. What is the angle between $\vec{a}$ and $\vec{b}$?

(a) 0° (b) 45° (c) 90° (d) 30° (e) 180°

4. What is the unit vector $\hat{e}_d$ in the direction of vector $\vec{d} = -2\hat{\imath} + \hat{\jmath} - 2\hat{k}$?

(a) $\frac{2}{3}\hat{\imath} + \frac{1}{3}\hat{\jmath} - \frac{2}{3}\hat{k}$ (b) $-\frac{2}{3}\hat{\imath} + \frac{1}{3}\hat{\jmath} - \frac{2}{3}\hat{k}$ (c) $-\frac{2}{3}\hat{\imath} + \frac{1}{3}\hat{\jmath} + \frac{2}{3}\hat{k}$ (d) $\frac{2}{3}\hat{\imath} - \frac{1}{3}\hat{\jmath} + \frac{2}{3}\hat{k}$ (e) $\frac{2}{3}\hat{\imath} + \frac{1}{3}\hat{\jmath} + \frac{2}{3}\hat{k}$

5. Consider an object with acceleration function $a(t) = 3t\ \mathrm{m/s^3} - 3\ \mathrm{m/s^2}$ with initial conditions $v(t = 0) = 1$ m/s and $x(t = 0) =$ 2m. What is the magnitude of the position of the object at $t = 1$ s?

(a) 2 m (b) 5 m (c) 4 m (d) 6 m (e) 3 m

6. Which step of the following derivation is wrong or includes an invalid operation for the time independent expression of motion with constant acceleration?

I. $\vec{s} = \vec{v}t$

II. $\vec{s} = \left[\frac{\vec{v}+\vec{v_0}}{2}\right] \cdot \left[\frac{\vec{v}-\vec{v_0}}{\vec{a}}\right]$

III. $2\vec{a} \cdot \vec{s} = (\vec{v} + \vec{v_0}) \cdot (\vec{v} - \vec{v_0})$

IV. $2\vec{a} \cdot \vec{s} = \vec{v} \cdot \vec{v} - \vec{v_0} \cdot \vec{v_0}$

V. $2\vec{a} \cdot \vec{s} = v^2 - v_0^2$

(a) III (b) IV (c) V (d) II (e) I

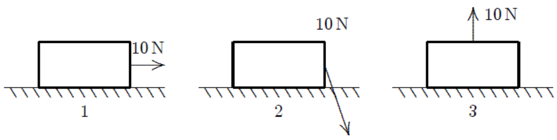
7. A cruise ship moves southward in still water at a speed of 20.0 km/h, while a passenger on the deck of the ship walks toward the east at a speed of 5.0 km/h. The passenger's velocity with respect to Earth is

(a) 20.6 km/h, west of south. (b) 25.0 km/h, east. (c) 20.6 km/h, south. (d) 25.0 km/h, south. (e) 20.6 km/h, east of south.

8. Sum of real forces acting on an astronaut who is inside a space shuttle circular orbiting the Earth is zero when the astronaut feels weightless. What can be said about the previous statement?

(a) Depends on the orbit. (b) True. (c) False. (d) If centrifugal force cancels the weight of the astronaut then it is true. (e) Depends on the kind of planet, e.g. Earth.

9. A box is pulled with a 10 N force by a woman, the crate moves 10 m to the right. Rank the situations shown below according to the work done by her force, least to greatest.



(a) 2, 1, 3 (b) 3, 2, 1 (c) 1, 3, 2 (d) 2, 3, 1 (e) 1, 2, 3

10. During a soccer game, a soccer ball is hit high into the upper rows of the tribunes. Over its entire flight the work done by gravity and the work done by air resistance, respectively, are:

(a) unknown, insufficient information (b) negative; positive (c) negative; negative (d) positive; negative (e) positive; positive

Questions 11-13

A rabbit runs in a garden such that the $x-$ and $y-$ components of its displacement as function of times are given by $x(t) = (5.0\ \mathrm{m/s})t + (6.0\ \mathrm{m/s^2})t^2$ and $y(t) = (7.0\ \mathrm{m}) - (3.0\ \mathrm{m/s^3})t^3$ (Both x and y are in meters and t is in seconds.)

11. Calculate the rabbit's velocity vector (m/s) at $t = 3.0$ s.

(a) $41\hat{\imath} - 81\hat{\jmath}$ (b) $41\hat{\imath} + 81\hat{\jmath}$ (c) $31\hat{\imath} - 81\hat{\jmath}$ (d) $31\hat{\imath} + 81\hat{\jmath}$ (e) $55\hat{\imath}$

12. Calculate the rabbit's acceleration vector ($\mathrm{m/s^2}$) at $t = 3.0$ s

(a) $54\hat{\imath} - 12\hat{\jmath}$ (b) $54\hat{\imath} + 12\hat{\jmath}$ (c) $12\hat{\imath} + 54\hat{\jmath}$ (d) $12\hat{\imath} - 54\hat{\jmath}$ (e) $54\hat{\imath}$

13. Calculate the rabbit's position vector at $t = 3.0$ s.

(a) $69\hat{\imath} - 20\hat{\jmath}$ (b) $69\hat{\imath} + 71\hat{\jmath}$ (c) $69\hat{\imath} + 74\hat{\jmath}$ (d) $69\hat{\imath} - 74\hat{\jmath}$ (e) $69\hat{\imath} - 71\hat{\jmath}$

Questions 14-15

A golf ball is kicked with an initial velocity of v_0 from the ground and initial angle of θ with respect to the horizontal. Assume the golf ball leaves the foot at ground level, and ignore air resistance and rotation of the ball.

14. How high will the golf ball be at the highest point of its trajectory?

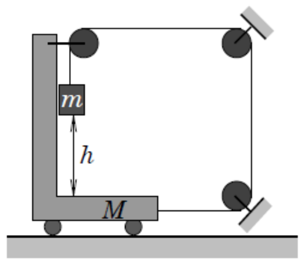
(a) $\frac{(v_0 \cos\theta)^2}{2g}$ (b) $\frac{(v_0 \cos\theta)^2}{g}$ (c) $\frac{(2v_0 \sin\theta)^2}{g}$ (d) $\frac{(v_0 \sin\theta)^2}{2g}$ (e) $\frac{\sqrt{v_0 \sin\theta}}{g}$

15. Where will the golf ball fall back to the ground?

(a) $\frac{v_0^2 \sin\theta}{2g}$ (b) $\frac{v_0^2 \cos\theta}{2g}$ (c) $\frac{v_0^2 \sin 2\theta}{g}$ (d) $\frac{v_0^2 \cos 2\theta}{g}$ (e) $\frac{v_0^2 \sin\theta \cos\theta}{g}$

Questions 16-20

The mass m is at rest at the beginning of the motion when it is h above the surface of M. The friction in all of the surfaces and the weight of pulleys will be neglected in this question. (Two pulleys at the right hand side are fixed and the pulley at left hand side is moving with M during the motion.)



16. What is the relationship between the x-component of the acceleration of m a_{mx} and the x-component of the acceleration of M a_{Mx}?

(a) $a_{mx} = a_{Mx}$ (b) $a_{mx} = 3a_{Mx}$ (c) $a_{mx} = 2a_{Mx}$ (d) $a_{mx} = a_{Mx}/3$ (e) $a_{mx} = a_{Mx}/2$

17. What is the relationship between the y-component of the acceleration of m a_{my} and the x-component of the acceleration of M a_{Mx}?

(a) $a_{my} = 3a_{Mx}$ (b) $a_{my} = a_{Mx}/3$ (c) $a_{my} = a_{Mx}/2$ (d) $a_{my} = 2a_{Mx}$ (e) $a_{my} = a_{Mx}$

18. Express the y-component of the acceleration of m a_{my} in terms of m, M and g.

(a) $4m\,g/(5m + M)$ (b) $5m\,g/(3m + 2M)$ (c) $5m\,g/(4m + M)$ (d) $2m\,g/(5m + M)$ (e) $4m\,g/(3m + M)$

19. Express the tension in the string in terms of m, M and g.

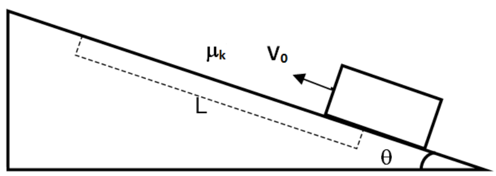
(a) $m\,g\,(m + M)/(5m + M)$ (b) $m\,g\,(m + M)/(4m + M)$ (c) $m\,g\,(m + M)/(3m + 2M)$ (d) $2m\,g\,(m + M)/(4m + M)$ (e) $2m\,g\,(m + M)/(5m + M)$

20. Express the time for mass m to reach the surface if M in terms of the acceleration of m, h and g.

(a) $\sqrt{2h\,g/a_{my}}$ (b) $\sqrt{2h/a_{mx}}$ (c) $\sqrt{2h\,g/a_{mx}}$ (d) $\sqrt{g\,h/2a_{my}}$ (e) $\sqrt{2h/a_{my}}$

Questions 21-25

A box drops down from a lorry while moving with a speed of 10 m/s on the road with inclination $\theta°$, where mass of the box and kinetic friction coefficient are 10 kg and μ_k, respectively. For the moment that the box slides up and reaches possible maximum height (L), find;
(take $g = 10\text{m/s}^2$)



21. Work done on the box by the net force

(a) 0.5 kJ (b) -0.5 kJ (c) -1 kJ (d) 0 kJ (e) 1 kJ

22. The distance that the box has taken during the slide

(a) $W_{net}/mg(\sin\theta - \mu_k \cos\theta)$ (b) $W_{net}/mg(\sin\theta + \mu_k \cos\theta)$ (c) $W_{net}/(\sin\theta - \mu_k \cos\theta)$ (d) $W_{net}/mg(\cos\theta + \mu_k \sin\theta)$ (e) $W_{net}/(\sin\theta + \mu_k \cos\theta)$

23. Work done on the box by gravitation

(a) $-mgL\mu_k \cos\theta$ (b) $mgL \sin\theta$ (c) $-mgL \tan\theta$ (d) $-mgL \sin\theta$ (e) $-mgL \cos\theta$

24. Work done on the box by normal force

(a) $mg(\cos\theta - \mu_k \sin\theta)$ (b) $mgL \sin\theta$ (c) 0 (d) $mg(\cos\theta + \mu_k \sin\theta)$ (e) $-mgL\mu_k \cos\theta$

25. Work done on the box by friction

(a) $-mg\mu_k L \sin\theta$ (b) mgL (c) $-mg\mu_k \cos\theta$ (d) $-mg\mu_k L \cos\theta$ (e) $-mgL \cos\theta$

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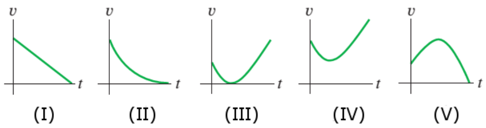
ATTENTION:Each question has only one correct answer and is worth one point. Be sure to fill in completely the circle that corresponds to your answer on the answer sheet. Use a pencil (not a pen). Only the answers on your answer sheet will be taken into account.

1. A simple pendulum (a mass swinging at the end of a string) starts swinging from right to left. What is the direction of the acceleration of the mass when it is at the left end of the swing?

(a) to the left (b) centrifugal (c) to the rotation axis (d) the tangential to the path (e) zero

2. A stone is thrown into the air at an angle above the horizontal and feels negligible air resistance. Which graph in the figure best depicts the stone's speed as a function of time t while it is in the air?



(a) II (b) III (c) V (d) IV (e) I

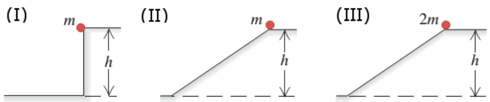
3. In uniform circular motion, how does the acceleration change when the speed is increased by a factor of 3 and the radius is decreased by factor 2?

(a) 18 (b) 36 (c) 1/18 (d) 9 (e) 1/36

4. An elevator is hoisted by its cables at constant speed. What is the total work done by cables and gravity on the elevator?

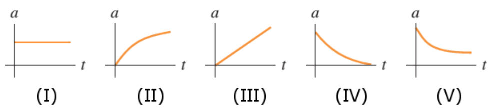
(a) Positive (b) Zero (c) Depends on number of cables (d) Negative (e) Undeterminable

5. Which statement is true for the masses sliding down from the various inclines shown in figure? There is no friction or air resistance!



(a) I will have the largest speed.
(b) They all have different speeds. (c) III will have the largest speed.
(d) They all have the same speed.
(e) I and II will have the same speed and it is going to be different from III.

6. A ball is dropped from rest and feels air resistance as it falls. Which of the graphs in figure best represents its acceleration as a function of time?

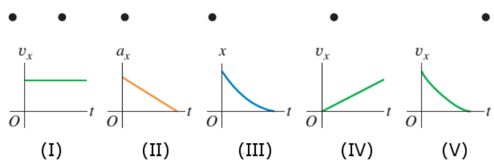


(a) V (b) IV (c) III (d) II (e) I

7. Which of the following statements is correct?
(1) The work done by any force might be positive or negative depending on the choice of the frame of reference.
(2) Any friction force will decrease the speed of the body in any reference frame.
(3) No friction force can do a positive work in any reference frame.

(a) 2,3 (b) 3 (c) 1 (d) None of them (e) 2

8. The top diagram in figure represents a series of highspeed photographs of an insect flying in a straight line from left to right (in the positive x-direction). Which of the graphs in figure most plausibly depicts this insect's motion?



(a) V (b) I (c) III (d) II (e) IV

Questions 9-11

$\vec{A} = 2\hat{i} + 3\hat{j} - \hat{k}$ and $\vec{B} = a\hat{i} - \hat{j} - 2\hat{k}$ vectors are given.

9. What should be the value of a to make $\vec{B}$ perpendicular to $\vec{A}$?

(a) 0 (b) 1/2 (c) -1 (d) 2 (e) 1

10. What is the unit vector in the direction of $\vec{A}$?

(a) $\frac{2\hat{i}+3\hat{j}-\hat{k}}{\sqrt{14}}$ (b) $\frac{2\hat{i}+3\hat{j}+\hat{k}}{\sqrt{12}}$ (c) $\frac{2\hat{i}-3\hat{j}-\hat{k}}{\sqrt{12}}$ (d) $\frac{-2\hat{i}+3\hat{j}-\hat{k}}{\sqrt{14}}$ (e) $\hat{i}+\hat{j}+\hat{k}$

11. What is the magnitude of the projection of $\vec{B}$ vector on $\vec{A}$ vector if a=1?

(a) $1/\sqrt{12}$ (b) $1/\sqrt{14}$ (c) $\sqrt{12}$ (d) $\sqrt{14}$ (e) $1/\sqrt{84}$

Questions 12-16

A balloon having 20 m/s constant velocity is rising up from ground vertically. When the balloon reaches 160 m height, an object is thrown horizontally with a velocity of 20 m/s with respect to balloon. Assume the mass of the object is small compared to the mass of the balloon. Take $g = 10\ m/s^2$.

12. What is the horizontal distance travelled by the object before it hits the ground.

(a) 80 m (b) 160 m (c) 40 m (d) 200 m (e) 240 m

13. What are the velocity components $(|V_x|, |V_y|)$ of the object when it hits the ground?

(a) $(60\ \frac{m}{s}, 20\ \frac{m}{s})$ (b) $(20\ \frac{m}{s}, 30\ \frac{m}{s})$ (c) $(20\ \frac{m}{s}, 40\ \frac{m}{s})$ (d) $(20\ \frac{m}{s}, 20\ \frac{m}{s})$ (e) $(20\ \frac{m}{s}, 60\ \frac{m}{s})$

14. How high is the balloon when the object hits the ground?

(a) 320 m (b) 220 m (c) 280 m (d) 260 m (e) 240 m

15. What is the maximum height of the object with respect to ground?

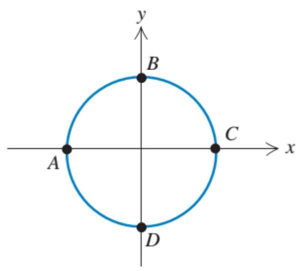
(a) 160 m (b) 180 m (c) 320 m (d) 240 m (e) 90 m

16. Find such a time that the displacement of the object and the balloon are the same after ejecting the object.

(a) 14 s (b) 16 s (c) 10 s (d) 4 s (e) 12 s

Questions 17-19

An athlete starts at point A and runs at a constant speed of 6.0 m/s around a circular track 200 m in diameter clockwise, as shown in figure. Take $\pi = 3$.



17. What is the average velocity of the runner for a complete turn (a lap) ?

(a) $0\ \frac{m}{s}$ (b) $6\ \frac{m}{s}$ (c) $4\ \frac{m}{s}$ (d) $5\ \frac{m}{s}$ (e) $200/6\ \frac{m}{s}$

18. What are the x and y components of the runner's average velocity between A and B ?

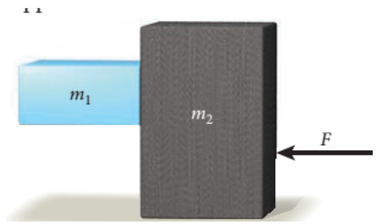
(a) $(6\ \frac{m}{s}, -4\ \frac{m}{s})$ (b) $(6\ \frac{m}{s}, 6\ \frac{m}{s})$ (c) $(8\ \frac{m}{s}, -8\ \frac{m}{s})$ (d) $(-4\ \frac{m}{s}, 6\ \frac{m}{s})$ (e) $(4\ \frac{m}{s}, 4\ \frac{m}{s})$

19. What are the x and y components of the runner's average acceleration $(a_x, a_y)_{av}$ between A and B ?

(a) $(12\ \frac{m}{s^2}, 4\ \frac{m}{s^2})$ (b) $(4\ \frac{m}{s^2}, 4\ \frac{m}{s^2})$ (c) $(\frac{6}{25}\ \frac{m}{s^2}, \frac{-6}{25}\ \frac{m}{s^2})$ (d) $(6\ \frac{m}{s^2}, -4\ \frac{m}{s^2})$ (e) $(-6\ \frac{m}{s^2}, 4\ \frac{m}{s^2})$

Questions 20-23

A block of mass m_1=2.00 kg is placed in front of a block of mass m_2=7.00 kg as shown in the figure. An F=360 N force is applied to the large object as seen in the figure. The coefficient of static friction between the blocks is 0.5 and there is no friction between the larger block and the tabletop. Take $g = 10\ m/s^2$.



20. What is the magnitude of the acceleration of the smaller block?

(a) $30\ m/s^2$ (b) $15\ m/s^2$ (c) $20\ m/s^2$ (d) $40\ m/s^2$ (e) $10\ m/s^2$

21. What is the magnitude of the normal force between the two blocks?

(a) 40 N (b) 70 N (c) 60 N (d) 80 N (e) 30 N

22. What is the magnitude of the friction force between the two blocks?

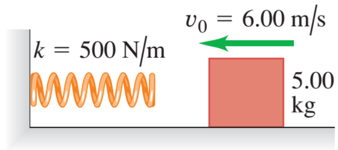
(a) 20 N (b) 25 N (c) 40 N (d) 35 N (e) 15 N

23. What is the magnitude of the normal force exerted by the table to the larger block?

(a) 10 N (b) 70 N (c) 180 N (d) 15 N (e) 90 N

Questions 24-25

A 5 kg block is moving at V_0 = 6.00 m/s along a frictionless, horizontal surface toward a spring with force constant k=500 N/m that is attached to a wall. The spring has negligible mass.



24. What is the maximum distance the spring will be compressed?

(a) 5 m (b) 1 m (c) $\frac{5}{3}$ m (d) $\frac{3}{5}$ m (e) 2 m

25. What is the speed of the block when it leaves the spring?

(a) $\sqrt{12.00}\ \frac{m}{s}$ (b) $\sqrt{6.00}\ \frac{m}{s}$ (c) $3.00\ \frac{m}{s}$ (d) $12.0\ \frac{m}{s}$ (e) $6.00\ \frac{m}{s}$

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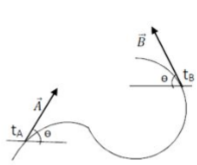
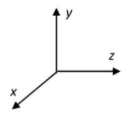
1. The position of a toy locomotive on a straight track along the x-axis is given by the equation $x(t) = t^3 - 6t^2 + 9t$, where x in meters and t is in seconds. When the path taken is the maksimum?
(a) $5s$ (b) $1s$ (c) $2s$ (d) $zero$ (e) $4s$

2. An object travels along a path shown in the figure, with changing velocity as indicated by vectors $\overrightarrow{A}$ and $\overrightarrow{B}$ with the same magnitude.Which vector best represents the average acceleration of the object from time t_A to t_B?
(a) $\swarrow$ (b) $\searrow$ (c) $\longleftarrow$ (d) $\longrightarrow$ (e) $\nwarrow$

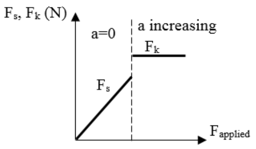


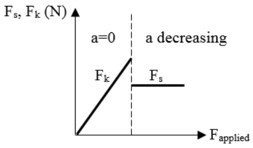
3. Which of the following is correct for the normal forces?
(a) its magnitude is always equal to the weight. (b) the value of the normal forces is different for static and kinetic frictions. (c) it is not determined if there is no friction. (d) the magnitude is higher than the weight if the surface is inclined. (e) it is always perpendicular to the surface.

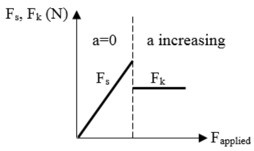
4. Which of the following is incorrect for the reference frame shown in figure. Here $\hat{i}$, $\hat{j}$, and $\hat{k}$ are the unit vectors for x, y, and z axis, respectively.
(a) $(\hat{j} \times \hat{i}) \bullet \hat{k} = +1$ (b) $(\hat{j} \times \hat{k}) \bullet \hat{i} = -1$ (c) $\hat{i} \times \hat{k} = \hat{j}$ (d) $(\hat{j} \times \hat{i}) \times \hat{k} = 0$ (e) $\hat{i} \times \hat{j} = \hat{k}$

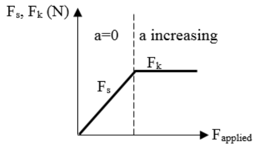


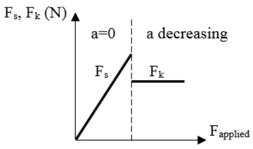
5. Which graph of the following is correct for F_s (static friction), and F_k (kinetic friction)?

(a) 

(b) 

(c) 

(d) 

(e) 

6. If the air resistance is negligible, the sum of the potential and the kinetic energies of a freely falling body ....
(a) decreases (b) increases (c) is zero (d) first increases and then decreases (e) remains the same

7. Which of the following are correct?

1. Spring force is a conservative force.
2. Work done by a conservative force is always zero.
3. Frictional force is a conservative force for a closed orbit.
4. The work done by a conservative force for a closed orbit is zero.

(a) 1,2 and 4 (b) 2 and 4 (c) 1 and 4 (d) All are true (e) only 1

8. Which of the following statement is false?
(a) The total energy is preserved in the friction environment.
(b) Change in the potential energy equals to negative of the work done by a conservative force.
(c) Change in the potential energy equals to the work done by a conservative force.
(d) Change in the kinetic energy is equal to the work done.
(e) Mechanical energy is conserved in a frictionless environment.

9. Which of the following is wrong about the uniform circular motion?
(a) Angular speed is constant. (b) Magnitude of the velocity vector is constant. (c) None. (d) Acceleration vector is constant. (e) Angular frequency is constant.

10. An object is thrown with horizontal speed $v_0 = 10\,m/s$ from a height H. If the range of the object is also equal to H, which of the following is the time passing until the object hit the ground? (Take $g = 10\,m/s^2$.)
(a) $1\,s$ (b) $2\,s$ (c) $3\,s$ (d) $1/2\,s$ (e) $1/3\,s$

11. Assume that the air pressure is calculated with the formula $P = \alpha h^x g^y d^z$ where α is a dimensionless constant, P is the pressure, h is the height, g is the gravitational acceleration, and d is the density of the air; x, y, and z are also numerical constants. What is the value of x?
(a) 1 (b) 3 (c) 2 (d) 3/2 (e) 1/2

Questions 12-16

For $\vec{A}$ and $\vec{B}$ vectors given as $\vec{A} = 2\hat{i} - 3\hat{j} + 4\hat{k}$ and $\vec{B} = -3\hat{i} - 4\hat{j} + \hat{k}$

12. Find a unit vector in the same direction with $\vec{B}$.
(a) $-3\hat{i} - 4\hat{j} + \hat{k}$ (b) $\frac{-3\hat{i}-4\hat{j}+\hat{k}}{\sqrt{8}}$ (c) $\frac{+3\hat{i}+4\hat{j}-\hat{k}}{\sqrt{8}}$ (d) $\frac{-3\hat{i}-4\hat{j}+\hat{k}}{\sqrt{26}}$ (e) $\frac{-3\hat{i}-4\hat{j}+\hat{k}}{2}$

13. Calculate $\vec{A} \bullet \vec{B}$?
(a) -14 (b) 4 (c) -12 (d) 10 (e) -16

14. Calculate $\vec{A} \times \vec{B}$?
(a) $14\hat{i} - 17\hat{j} - 10\hat{k}$ (b) $14\hat{i} - 13\hat{j} - 17\hat{k}$ (c) $13\hat{i} - 14\hat{j} - 17\hat{k}$ (d) $-13\hat{i} + 14\hat{j} - 17\hat{k}$ (e) $-13\hat{i} + 14\hat{j} + 17\hat{k}$

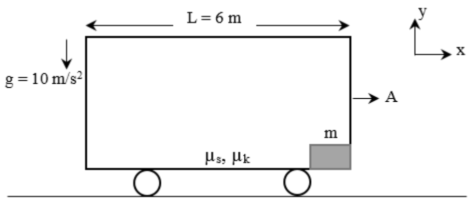
15. Find a unit vector, $\hat{c}$, which is perpendicular to the plane formed by $\vec{A}$ and $\vec{B}$ vectors.

(a) $\hat{c} = \pm\frac{14\hat{i}-13\hat{j}-17\hat{k}}{\sqrt{(13)^2+(-14)^2+(-17)^2}}$ (b) $\hat{c} = \pm\frac{13\hat{i}+14\hat{j}-17\hat{k}}{\sqrt{(13)^2+(-14)^2+(-17)^2}}$ (c) $\hat{c} = \pm\frac{14\hat{i}-17\hat{j}-10\hat{k}}{\sqrt{(13)^2+(-14)^2+(-17)^2}}$ (d) $\hat{c} = \pm\frac{13\hat{i}-14\hat{j}-17\hat{k}}{\sqrt{(13)^2+(-14)^2+(-17)^2}}$
(e) $-13\hat{i} + 14\hat{j} + 17\hat{k}$

16. Calculate the cosine of the angle between $\vec{A}$ and $\vec{B}$ vectors.
(a) $\frac{-14}{\sqrt{29}\cdot\sqrt{26}}$ (b) $\frac{10}{\sqrt{29}\cdot\sqrt{26}}$ (c) $\frac{-16}{\sqrt{29}\cdot\sqrt{26}}$ (d) $\frac{-4}{\sqrt{29}\cdot\sqrt{26}}$ (e) $\frac{-12}{\sqrt{29}\cdot\sqrt{26}}$

Questions 17-21

A truck of length $L = 6\ m$, initially at rest, starts moving with a constant acceleration A at $t = 0$. A block of mass $m = 2\ kg$ inside the truck is initially at rest and *barely touching* the front wall of the truck. The coefficient of static and kinetic frictions between the block and the truck are $\mu_s = 0.8$ and $\mu_k = 0.6$, respectively ($g = 10\ m/s^2$).



17. Which of the following is the minimum value of the A such that the block m starts sliding?
(a) $5\ m/s^2$ (b) $7\ m/s^2$ (c) $9\ m/s^2$ (d) $6\ m/s^2$ (e) $8\ m/s^2$

18. If $A = 9\ m/s^2$, which of the following is the acceleration vector of the block with respect to the truck?
(a) $2\hat{i}\ m/s^2$ (b) $3\hat{i}\ m/s^2$ (c) $-3\hat{i}\ m/s^2$ (d) $-2\hat{i}\ m/s^2$ (e) $-3/2\hat{i}\ m/s^2$

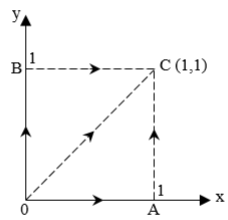
19. If $A = 6\ m/s^2$, which of the following is the magnitude of the friction force acting on the block?
(a) 10 N (b) 12 N (c) 8 N (d) 14 N (e) 16 N

20. If $A = 9\ m/s^2$, which of the following is the time required for the block to reach the back side of the truck?
(a) 2 s (b) 3 s (c) $\sqrt{3}\ s$ (d) $\sqrt{2}\ s$ (e) 1 s

21. If $A = 9\ m/s^2$, which of the following is the velocity vector of the block with respect to the ground when it reaches the back side?
(a) $12\hat{i}\ m/s$ (b) $-10\hat{i}\ m/s$ (c) $-8\hat{i}\ m/s$ (d) $10\hat{i}\ m/s$ (e) $8\hat{i}\ m/s$

Questions 22-25

A variable force acting on a particle of mass m moving in the xy-plane is given by $\vec{F}(x, y) = ax^2\hat{i} + by^2\hat{j}$ where a and b are constants. This particle moves from origin to point C with coordinates $(1, 1)$ through the three different paths: $O \to A \to C$, $O \to B \to C$, and $O \to C$.



22. Find the work done by $\vec{F}$ when the particle takes the path $O \to A \to C$, W_{OAC}=?
(a) $(2a + b)/3$ (b) $(a + 2b)/3$ (c) $(a - b)/3$ (d) $(2a - b)/3$ (e) $(a + b)/3$

23. Find the work done by $\vec{F}$ when the particle takes the path $O \to B \to C$, W_{OBC}=?
(a) $(a + b)/3$ (b) $(2a - b)/3$ (c) $(2a + b)/3$ (d) $(a + 2b)/3$ (e) $(a - b)/3$

24. Find the work done by $\vec{F}$ when the particle takes the path $O \to C$, W_{OC}=?
(a) $(a - b)/3$ (b) $(2a + b)/3$ (c) $(a + 2b)/3$ (d) $(a + b)/3$ (e) $(2a - b)/3$

25. Which of the followings are true?
1. This force can be a conservative force. **2.** This force can be a kind of frictional force. **3.** $W_{OACBO} = 0$.
4. $W_{OBCO} = b - a$.
(a) 2 (b) 1, 4 (c) 2, 4 (d) 1, 3 (e) 3, 4

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ATTENTION:Each question has only one correct answer and is worth one point. Be sure to fill in completely the circle that corresponds to your answer on the answer sheet. Use a pencil (not a pen). Only the answers on your answer sheet will be taken into account.

1. Which of the following is not one of the fundamental physical quantities in the SI system?

(a) force (b) length (c) mass (d) time (e) All of the these are fundamental physical quantities.

Questions 2-5

Time dependent position vectors of two particles are given by $\vec{a} = t\hat{\imath} + 2\hat{\jmath} + \hat{k}$ and $\vec{b} = \hat{\imath} - t\hat{\jmath} + 2\hat{k}$. Here t represents time in seconds and the magnitudes of vectors $\vec{a}$ and $\vec{b}$ are in meters.

2. At which instant in time $\vec{a}$ is perpendicular to $\vec{b}$?

(a) t=4 s (b) t=5 s (c) t=2 s (d) t=1 s (e) t=3 s

3. Which of the following is a unit vector, that is perpendicular to the plane spanned by vectors $\vec{a}$ and $\vec{b}$, at t=0?

(a) $\frac{2\hat{\imath}-3\hat{\jmath}+5\hat{k}}{\sqrt{36}}$ (b) $\frac{4\hat{\imath}+3\hat{\jmath}+2\hat{k}}{\sqrt{23}}$ (c) $\frac{2\hat{\imath}+4\hat{\jmath}-2\hat{k}}{\sqrt{24}}$ (d) $\frac{4\hat{\imath}+\hat{\jmath}-2\hat{k}}{\sqrt{21}}$ (e) $\frac{\hat{\imath}+\hat{\jmath}-2\hat{k}}{\sqrt{6}}$

4. Which of the following is the distance between the two particles at t=3 s?

(a) 30 m (b) 28 m (c) $\sqrt{30}$ m (d) $\sqrt{29}$ m (e) $\sqrt{28}$ m

5. Which of the following is the position vector of the first particle relative to the second one at t=3 s?

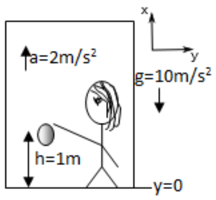
(a) $2\hat{\imath} + 5\hat{\jmath} - \hat{k}$ (b) $3\hat{\imath} + 4\hat{\jmath} - 1\hat{k}$ (c) $4\hat{\imath} + 5\hat{\jmath} - 3\hat{k}$ (d) $4\hat{\imath} + 3\hat{\jmath} + 2\hat{k}$ (e) $2\hat{\imath} - 3\hat{\jmath} + 5\hat{k}$

6. A ball is thrown vertically upward, reaches its highest point and falls back down. Which of the following statements is true?

(a) The acceleration is always in the direction of motion. (b) The acceleration is always directed down. (c) At the highest point the velocity and acceleration of the particle are both nonzero. (d) The acceleration is always directed up. (e) The acceleration is always opposite to the velocity.

Questions 7-11

A girl is holding a ball as she steps onto a tall elevator on the ground floor of a building. She holds the ball at a height of 1 meter above the elevator floor. The elevator begins accelerating upward from rest at 2 m/s^2 in +y direction. After the elevator accelerates for 10 seconds (Take g = 10 m/s^2, $6^{-1/2}$ = 0.4),



7. Find the speed of the elevator.

(a) 25 m/s. (b) 15 m/s. (c) 20 m/s. (d) 5 m/s. (e) 30 m/s.

8. Find the height of the floor of the elevator above the ground.

(a) 75 m. (b) 100 m. (c) 200 m. (d) 150 m. (e) 50 m.

At the end of 10 s, the girl releases the ball from a height of 1 meter above the floor of the elevator. If the elevator continues to accelerate upward at 2 m/s^2,

9. Find the acceleration of the ball relative to the elevator.

(a) -8 m/s^2 (b) -12 m/s^2 (c) 12 m/s^2 (d) -10 m/s^2 (e) 8 m/s^2

10. What is the time needed the ball hits the floor after the ball is released ?

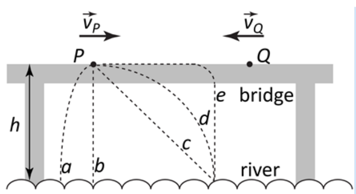
(a) 0.4 s (b) 0.2 s (c) 2 s (d) 2.5 s (e) 0.3 s

11. What is the elevator's approximate height (h) above the ground when the ball hits the elevator's ground?

(a) 8 m. (b) 4 m. (c) 174 m. (d) 100 m. (e) 108 m.

Questions 12-15

Harry is running with a constant speed $v_P = 3$ m/s across a horizontal bridge of height $h = 5$ m as shown in the figure. When he passes point P, he opens his hand and drops a rock into the river. In the following calculations, take $g = 10\,m/s^2$.



12. If you are standing at point P, which one of the trajectories shown in the figure best describes the path of the rock you are observing?

(a) Path b (b) Path a (c) Path e (d) Path d (e) Path c

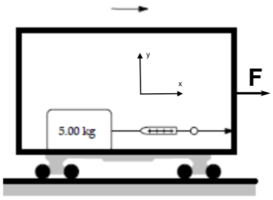
13. What horizontal distance does the rock travel from point P to the point where it hits the river?
(a) 6 m (b) 3 m (c) 10 m (d) 5 m (e) 1.5 m

14. What is the speed of the rock at the point where it hits the river?
(a) $\sqrt{109}$ m/s (b) 3 m/s (c) 13 m/s (d) 10 m/s (e) 5 m/s

15. Suppose Sally is running in the direction opposite to Harry with a constant speed $v_Q = 2$ m/s . She passes point Q located 2 m to the right of point P at the same time when Harry passes point P, opens her hand, and drops another rock into the river. What is the horizontal distance between the points where the two rocks dropped by Harry and Sally hit the river?
(a) 3 m (b) 2 m (c) 0 (d) 5 m (e) 1 m

Questions 16-18

A 5kg mass attached to a spring scale rest on a frictionless, horizontal surface. The spring scale attached to the front end of a boxcar, reads 20 N when the car is in motion and 0 N when it is at rest. The mass of boxcar is 10 kg.



16. In which type of frame of reference is Newton's first law obeyed?

I. Noninertial frame of reference. II. Inertial frame of reference. III. Frame of reference that is accelerating. IV. Frame of reference that is moving along a curve.

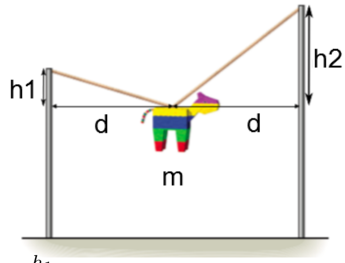
(a) none of them (b) only III (c) only II (d) I and III (e) II and III

17. Determine the acceleration of the car.
(a) $-\frac{4}{3}\hat{i}$ m/s^2 (b) $\frac{4}{3}\hat{i}$ m/s^2 (c) $4\hat{i}$ m/s^2 (d) $2\hat{i}$ m/s^2 (e) $-4\hat{i}$ m/s^2

18. What will the spring scale read if the car moves with constant velocity?
(a) 0 N (b) 10 N (c) 4 N (d) 6 N (e) −20 N

Questions 19-20

A toy horse of mass m is attached to a rope of negligible mass that is strung between the tops of two vertical poles as shown in the figure.



19. What is the relation between the tensions in the left (T_1) and right (T_2) sides of the rope?

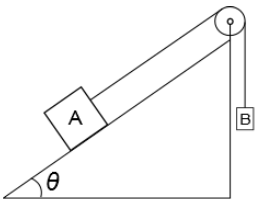
(a) $T_1 = T_2\frac{h_2^2}{h_1^2}$ (b) $T_1 = T_2\sqrt{\frac{h_1^2+d^2}{h_2^2+d^2}}$ (c) $T_1 = T_2\frac{h_1^2}{h_2^2}$ (d) $T_1 = T_2$ (e) $T_1 = T_2\sqrt{\frac{h_2^2+d^2}{h_1^2+d^2}}$

20. What is T_1?

(a) $T_1 = 2mg\frac{\sqrt{h_1^2+d^2}}{h_1+h_2}$ (b) $T_1 = mgh_1$ (c) $T_1 = mg\frac{\sqrt{h_1^2+d^2}}{h_1+h_2}$ (d) $T_1 = \sqrt{\frac{h_1^2+d^2}{h_2^2+d^2}}$ (e) $T_1 = mg\frac{h_1}{h_2}$

Questions 21-24

Block A of mass 2.0 kg is on an inclined plane with inclination $\theta = 37^o$ ($\sin\theta = 3/5$). It is attached with a string passing over a massless and frictionless pulley to block B of mass 1.0 kg. The coefficients of static and kinetic friction between block A and the inclined plane are μ_s=0.6 and μ_k=0.5, respectively. Gravitational acceleration is assumed to be 10 m/s^2. The system is released from rest. Assume that the static friction case holds:



21. What is the static friction force on block A?

(a) 9.6 N downhill (b) 9.6 N uphill (c) 0 (d) 2 N downhill (e) 2 N uphill

22. Is the static friction assumption valid or not and why?

(a) Yes, $f_s < \mu_s$N (b) Yes, $f_s = \mu_s$N (c) Yes, $f_s > \mu_s$ (d) No, $f_s > \mu_s$ (e) No, $f_s < \mu_s$

Now the blocks are given an initial velocity (hanging block downward, 2.0 kg block upward) of 1.0 m/s.

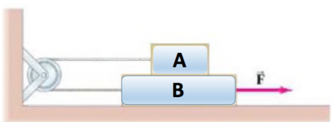
23. What is the acceleration of the hanging block in m/s^2

(a) 13/3 upward (b) 10/3 downward (c) 13/3 downward (d) 0 (e) 10/3 upward

24. How much will the blocks move until they stop (in meters)?

(a) 1 (b) they will not stop (c) 1/2 (d) 13/6 (e) 3/26

25. Consider the system shown in figure on the right. Block A sits on top of block B which is on a horizontal surface. The block B is pulled to the right with a force F. The coefficient of kinetic friction between all surfaces is μ_k. What is the acceleration of the system? Hint: Assume that the force is enough to move the system.



(a) $\mu_k(3m_A + m_B)g$ (b) $\frac{F-\mu_k(m_A+3m_B)g}{(m_A+3m_B)}$ (c) $\frac{2F-\mu_k(m_A+m_B)g}{(m_A+m_B)}$ (d) $\frac{F-\mu_k(3m_A+m_B)g}{(m_A+m_B)}$ (e) $\mu_k(m_A + 3m_B)g$

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ATTENTION:Each question has only one correct answer and is worth one point. Be sure to fill in completely the circle that corresponds to your answer on the answer sheet. Use a pencil (not a pen). Only the answers on your answer sheet will be taken into account.

Questions 1-3

Two vectors are given as $\vec{A} = a\hat{\imath} - 2\hat{k}$ and $\vec{B} = b\hat{\jmath} - 2\hat{k}$ where a and b are positive real numbers.

1. If the magnitudes of vectors are $A = 3$ and $B = 4$, find magnitude of the vector $\vec{A} - \vec{B}$.

(a) -4 (b) $\sqrt{17}$ (c) 12 (d) 5 (e) -$\sqrt{17}$

2. Angle between the vectors $\vec{A}$ and $\vec{B}$ is

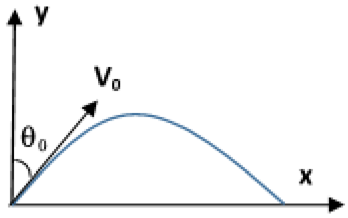
(a) $\arctan\sqrt{5/12}$ (b) $\arccos 1/3$ (c) $\arctan\sqrt{12/5}$ (d) 37° (e) 53°

3. Find a unit vector which is perpendicular to both vectors $\vec{A}$ and $\vec{B}$.

(a) $(\sqrt{12}\hat{\imath} + \sqrt{5}\hat{\jmath} + \sqrt{15}\hat{k})/\sqrt{32}$ (b) $(3\hat{\imath} + 4\hat{\jmath})/5$ (c) $2(\hat{\imath} + \hat{\jmath} - \hat{k})$ (d) $-\sqrt{5}\hat{\imath} + \sqrt{12}\hat{\jmath}$ (e) $(-\sqrt{5}\hat{\imath} + \sqrt{12}\hat{\jmath})/\sqrt{17}$

Questions 4-9

An object is thrown from ground with initial speed $V_0 = 10$ m/s at an angle $\theta_0 = 30°$ with the vertical axis as shown in the figure. (Ignore air resistance and take, g ≈ 10 m/s^2, $\sin 30° = 1/2$)



4. What is the acceleration of the object at the highest point?

(a) $\vec{a} = g\hat{\jmath}$ (b) $\vec{a} = g\hat{\imath}$ (c) $\vec{a} = -g\hat{\jmath}$ (d) $\vec{a} = 0$ (e) $\vec{a} = 2g\hat{\jmath}$

5. What is the maximum height that the object can reach?

(a) 15m (b) 5/4m (c) 1/2m (d) 15/4m (e) 5m

6. What is the time for the object to reach the maximum height?

(a) 15/4s (b) 5/4s (c) 1/2s (d) 2s (e) $\sqrt{3}/2$s

7. What is the horizontal range that the object can reach?

(a) 10m (b) $20\sqrt{3}$m (c) $10\sqrt{3}$m (d) 5m (e) $5\sqrt{3}$m

8. A little time after the take-off, the object passes from point (x=$\sqrt{3}$m, y). What is y?

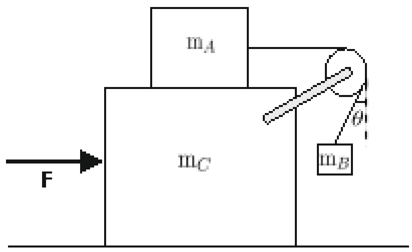
(a) $3\sqrt{3}$m (b) $(\sqrt{3} - 1)$m (c) $\sqrt{3}/2$m (d) 12/5m (e) 1m

9. What is the velocity (in m/s) of the object when it hits the ground?

(a) $-5\hat{\imath} + 5\sqrt{3}\hat{\jmath}$ (b) $5\sqrt{3}\hat{\imath} + 5\hat{\jmath}$ (c) $5\hat{\imath} + 5\sqrt{3}\hat{\jmath}$ (d) $5\hat{\imath} - 5\sqrt{3}\hat{\jmath}$ (e) $-5\hat{\imath} - 5\sqrt{3}\hat{\jmath}$

Questions 10-14

A block of mass m_A=3 kg rests on another block of mass m_C=5 kg. Block m_A is connected by a thin string that passes over a pulley to a third block of mass m_B=1 kg. A force $\vec{\mathbf{F}}$ is exerted on the large block m_C so that the mass m_A does not move relative to m_C. Ignore all friction. Assume m_B does not make contact with m_C. g = 10 m/s^2.



10. What is the tension (in units of N) in the string in terms of the acceleration (a) of the system?

(a) 3a (b) 2a (c) 4a (d) a (e) 5a

11. What is the tension (in units of N) in the string?

(a) $\frac{10}{\cos\theta}$ (b) 40 (c) 20 (d) 10 (e) $\frac{10}{\sin\theta}$

12. What is the value of $\sin\theta$?

(a) 3/5 (b) 1/3 (c) 0.5 (d) $\frac{\sqrt{3}}{2}$ (e) 2/5

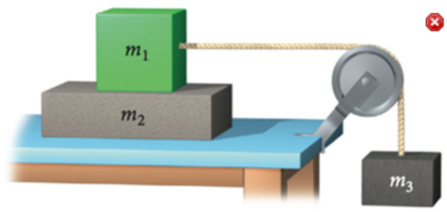
13. What is the magnitude of $\vec{\mathbf{F}}$ in units of N?

(a) 120 (b) 30 (c) $\frac{90}{\sqrt{8}}$ (d) 50 (e) 60

14. What is the acceleration (in m/s^2) of the block of mass m_B?

(a) $\frac{10}{3}$ (b) $\frac{20}{3}$ (c) $\frac{10}{\sqrt{8}}$ (d) $\frac{40}{3}$ (e) $\frac{50}{\sqrt{8}}$

Questions 15-19



Two blocks with masses m_1 and m_2 ($m_1\mu_s < m_2$) are on a frictionless table, and the blocks with masses, m_1 and m_3 are connected by a string as shown in the figure. The coefficients of static and kinetic friction between m_1 and m_2 are μ_s and μ_k, respectively. The three blocks are initially at rest and then left free to move.

15. If block m_1 slips on block m_2 what is the force of kinetic friction?

(a) $\frac{(-\mu_k m_1 - m_3)g}{m_1 - m_3}$ (b) $\frac{(-\mu_k m_1 - \mu_k m_2 + m_3)g}{m_1 + m_2 + m_3}$ (c) $\frac{\mu_k m_1 g}{m_1 + m_2 + m_3}$ (d) $\mu_k m_1 g$
(e) $\frac{(-\mu_k m_1 - \mu_k m_2 + m_3)g}{m_1 + m_2 - m_3}$

16. If block m_1 slips on block m_2 what is the acceleration of m_2?

(a) $\mu_k g \frac{m_1 - m_2}{m_2}$ (b) $\mu_k g \frac{m_1}{m_2}$ (c) $\mu_k g \frac{m_2}{m_1 + m_2}$ (d) $\mu_k g \frac{m_1 + m_2}{m_2}$ (e) $\mu_k g \frac{m_1}{m_1 + m_2}$

17. If block m_1 slips on block m_2 what is the acceleration of m_3?

(a) $\frac{(-\mu_k m_1 - \mu_s m_2 + m_3)g}{m_1 + m_2 + m_3}$ (b) $\frac{(-\mu_k m_1 - \mu_k m_2 + m_3)g}{m_1 + m_2 + m_3}$ (c) $\frac{(-\mu_k m_1 - m_3)g}{m_1 - m_3}$ (d) $\frac{(-\mu_k m_1 + m_3)g}{m_1 + m_3}$ (e) $\frac{(-\mu_k m_1 - \mu_k m_2 + m_3)g}{m_1 + m_2 - m_3}$

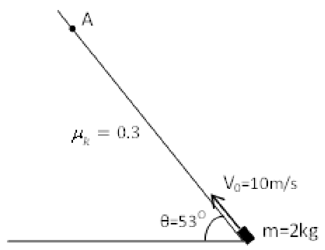
18. If block m_1 slips on block m_2 what is the tension in the string?

(a) $\frac{m_1 m_3 g}{m_1 + m_3}(1 + \mu_k)$ (b) $\frac{m_1 m_3 g}{m_2}(1 + \mu_s)$ (c) $\frac{m_3 g}{m_1 + m_3}(1 + \mu_s)$ (d) $\frac{m_1 g}{m_1 + m_3}(1 + \mu_s)$ (e) $\frac{m_1 m_2 m_3 g}{m_1 + m2 + m_3}(1 + \mu_k)$

19. What is the condition to be satisfied for the blocks with masses m_1 and m_2 move together without slipping?

(a) $m_3 \leq \mu_s \frac{m_2}{m_1}(-m_1 + m_2)$ (b) $m_3 \leq \frac{m_1(m_1 + m_2)\mu_s}{m_2 - m_1\mu_s}$ (c) $m_3 \leq \mu_s(m_1 + m_2)$ (d) $m_3 \leq \mu_k \frac{m_1}{m_2}(m_1 + m_2)$ (e) $m_3 \leq \mu_k \frac{m_2}{m_1}(-m_1 + m_2)$

Questions 20-25



An object of mass m=2kg is thrown up with the speed 10 m/s on an inclined surface of angle 53° as shown in the figure. The kinetic friction coefficient between the object and the surface is 0.3. (Take cos53° = 0.6, sin53° =0.8 and gravitational acceleration g=10 m/s^2)

20. What is the work (in Joule, J) done by the friction when the object reaches the point A, at a distance of 2 m from its initial point?

(a) +12 (b) +9.6 (c) -3.6 (d) 0 (e) -7.2

21. What is the work (in Joule) done by normal force up to the point A?

(a) +12 (b) 0 (c) +7.2 (d) +3.6 (e) -3

22. What is the work (in Joule) done by the net force up to the point A?

(a) -39.2 (b) -10.8 (c) +10.8 (d) +39.2 (e) -32

23. What is the speed (in m/s) of the object at the point A?

(a) $\sqrt{10.8}$ (b) $\sqrt{39.2}$ (c) $\sqrt{32}$ (d) $\sqrt{60.8}$ (e) $\sqrt{89.2}$

24. What is the approximate value of the distance (in m) that the object can travel on the inclined surface?

(a) 5.1 (b) 10.2 (c) 4.0 (d) 3.6 (e) 7.2

25. When the object turns back to its shooting point what is the speed (in m/s) of the object approximately?

(a) 5 (b) 6 (c) $\sqrt{63.3}$ (d) $\sqrt{36.7}$ (e) $\sqrt{18.4}$

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ATTENTION: Each question has only one correct answer and is worth one point. Be sure to fill in completely the circle that corresponds to your answer on the answer sheet. Use a pencil (not a pen). Only the answers on your answer sheet will be taken into consideration.

Questions 1-11

1. Given the two vectors $\vec{A} = 2\hat{\imath} - 3\hat{\jmath}$ and $\vec{B} = -\hat{\imath} + y\hat{\jmath}$, find the value of y such that $\vec{A}$ and $\vec{B}$ are orthogonal?
(a) -3/2 (b) -2/3 (c) 2/3 (d) 1/3 (e) 3/2

2. Pressure is force per unit area, its SI unit is Pascal (Pa). Therefore;
(a) 1Pa=1J m (b) 1Pa=1J/ m^2 (c) 1Pa=1J m^3 (d) 1Pa=1J/m^3 (e) 1Pa=1J m^2

3. In uniform circular motion, velocity is (a) perpendicular to acceleration vector. (b) parallel to acceleration vector. (c) in the opposite direction to position. (d) radially outward. (e) radially inward.

4. Which of the following is true for the instantaneous velocity?
(a) The instantaneous velocity is also called as average velocity.
(b) It equals the instaneous rate of change of its acceleration vector.
(c) It equals the limit of the average velocity as the time interval goes to infinity.
(d) The instantaneous velocity is tangent to the particle's path.
(e) Each component of a particle's instantaneous velocity is equal to each other.

5. For motion with acceleration, which of the following is correct?
(a) A body with constant acceleration can not remain stationary. (b) If the speed is negative then the acceleration is negative. (c) A body with constant acceleration can remain stationary. (d) If the speed is positive then the acceleration is positive. (e) If the speed is zero then the acceleration is zero.

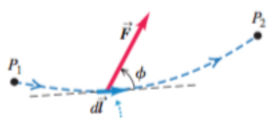
6. Consider a rock dropped from rest and falling through a fluid (e.g. water) with a fluid resistance. Which of the following is correct?

(a) The speed is always constant and is equal to the terminal speed.
(b) The speed decreases until terminal speed is reached.
(c) The speed first decreases than increases until terminal speed is reached.
(d) The speed first increases than decreases until terminal speed is reached.
(e) The speed increases until terminal speed is reached.

7. A man in an elevator drops the bag he is holding. If the bag does not fall to the floor of the elevator which of the following may be true?
I. Elevator is in free fall. II. Elevator is at constant speed. III. Elevator is accelerating downward with acceleration g. IV. Elevator is accelerating upward with g.
(a) I and IV (b) II and III (c) I and III (d) I and II (e) II and IV

8. A 10000 N automobile is pushed along a level road by four students who apply a total forward force of 500 N. Neglecting friction and taking $g = 10$ m/s^2, the acceleration of the automobile is:
(a) 0.5 m/s^2 (b) 10 m/s^2 (c) 5 m/s^2 (d) 20 m/s^2 (e) 2 m/s^2

9. According to the figure for motion along a curve, the corresponding work from P_1 to P_2 can be calculated as:



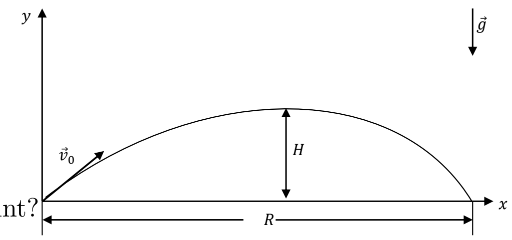
(a) $W = \int_{P_2}^{P_1} F \mathrm{d}l$ (b) $W = -\int_{P_1}^{P_2} F \sin\phi \mathrm{d}l$ (c) $W = -\int_{P_1}^{P_2} F \cos\phi \mathrm{d}l$
(d) $W = \int_{P_1}^{P_2} F \sin\phi \mathrm{d}l$ (e) $W = \int_{P_1}^{P_2} F \cos\phi \mathrm{d}l$

10. An elevator is pulled upward with a cable at constant velocity. The work done by the cable on the elevator
(a) is zero. (b) is positive. (c) is equal to the total work done on the elevator. (d) is negative. (e) is equal two times the total work done on the elevator.

11. Two objects interact only with each other. Initial speeds at the starting point are 5m/s for object A and 10m/s for object B. After some time, while they pass from their starting positions, A has a speed of 4m/s and B has a speed of 7m/s. What can be concluded?
(a) mechanical energy was increased by nonconservative force
(b) mechanical energy was increased by conservative forces
(c) mechanical energy was decreased by conservative forces
(d) the potential energy changed from the beginning to the end of the trip
(e) mechanical energy was decreased by nonconservative forces

Questions 12-16

A ball is thrown with an initial velocity $\vec{v}_0$, directed at an angle θ with the ground. The velocity vector of the ball at a height 5 m from the ground is given as $\vec{v} = (10\hat{\imath} - \sqrt{44}\hat{\jmath})$ m/s. (Take $g = 10$ m/s^2.)



12. What is the initial velocity $\vec{v}_0$ of the ball in m/s?

(a) $5\hat{\imath} + 12\hat{\jmath}$ (b) $5\hat{\imath} + 10\hat{\jmath}$ (c) $12\hat{\imath} + 5\hat{\jmath}$ (d) $10\hat{\imath} + 12\hat{\jmath}$ (e) $12\hat{\imath} + 10\hat{\jmath}$

13. What is the position vector of the ball in m when it reaches the highest point?

(a) $24\hat{\imath} + 7.2\hat{\jmath}$ (b) $12\hat{\imath} + 14.4\hat{\jmath}$ (c) $12\hat{\imath} + 7.2\hat{\jmath}$ (d) $24\hat{\imath} + 14.4\hat{\jmath}$ (e) $12\hat{\imath} + 24\hat{\jmath}$

14. What is the equation of the trajectory of the ball?

(a) $y = 1.2x - x^2/20$ (b) $y = 12x - x^2/100$ (c) $y = 12x - x^2/20$ (d) $y = 10x - x^2/20$ (e) $y = 1.2x - x^2/100$

15. How many seconds does it take for the ball to reach a height of $y = 63/20$ m?

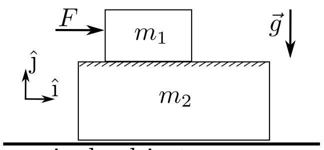
(a) 1 and 2 (b) 0.3 and 0.6 (c) 2.1 and 4.2 (d) 0.6 and 4.2 (e) 0.3 and 2.1

16. When the ball reaches the point $x = 3$ m and $y = 63/20$ m over the time interval, what is the average velocity $\Delta\vec{v}$ of the ball in m/s from the initial point?

(a) $10\hat{\imath} + 10.5\hat{\jmath}$ (b) $1.5\hat{\imath} + 1.5\hat{\jmath}$ (c) $1.6\hat{\imath} + 1.75\hat{\jmath}$ (d) $5\hat{\imath} + 5.25\hat{\jmath}$ (e) $10\hat{\imath} + 10\hat{\jmath}$

Questions 17-21

A block of $m_1 = 2.0\ kg$ is initially at rest on a slab of mass $m_2 = 4.0\ kg$, and a constant horizontal force F is applied on m_1, as shown in the figure. There is no friction between the ground and the slab but the coefficient of static and kinetic friction between the blocks are $\mu_s = 0.8$ and $\mu_k = 0.6$, respectively. (Take $g = 10.0\ m/s^2$.)



17. Find the maximum value of the force F for which m_1 will not slide off m_2 and they move as a single object.
(a) 16 N (b) 22 N (c) 24 N (d) 18 N (e) 26 N

18. If $F = 18\ N$, find the accelerations of the blocks in m/s^2.
(a) $a_1 = 2$ and $a_2 = 4$ (b) $a_1 = a_2 = 3$ (c) $a_1 = a_2 = 2$ (d) $a_1 = 3$ and $a_2 = 2$ (e) $a_1 = a_2 = 4$

19. If $F = 18\ N$, which of the following is the force applied by m_1 on m_2?
(a) $14\hat{\imath} - 18\hat{\jmath}\ N$ (b) $-12\hat{\imath} - 18\hat{\jmath}\ N$ (c) $-16\hat{\imath} + 18\hat{\jmath}\ N$ (d) $-12\hat{\imath} - 16\hat{\jmath}\ N$ (e) $12\hat{\imath} - 20\hat{\jmath}\ N$

20. If $F = 21\ N$, find the magnitude of the friction between the blocks.
(a) 16 N (b) 15 N (c) 14 N (d) 12 N (e) 13 N

21. If $F = 26\ N$, find the acceleration of m_1 relative to m_2.
(a) $-3\hat{\imath}\ m/s^2$ (b) $2\hat{\imath}\ m/s^2$ (c) $4\hat{\imath}\ m/s^2$ (d) $3\hat{\imath}\ m/s^2$ (e) $-2\hat{\imath}\ m/s^2$

Questions 22-25

22. Stretching a non-linear spring requires an amount of work given by the equation $U(x) = 15x^2 - 10x^3$, where U is in Joules and x is in meters units. How much force is required to hold this spring stretch out 2.0 m from its equilibrium position?

(a) 400 N (b) 5 N (c) 20 N (d) 120 N (e) 60 N

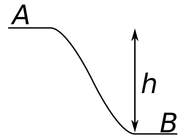
23. The behavior of a non-linear spring is described by the relationship $F = -2kx^3$, where x is the displacement from the equilibrium position and F is the force exerted by the spring. How much potential energy is stored when it is displaced a distance x from its equilibrium position?

(a) $kx^4/2$ (b) $6kx^2$ (c) $kx^3/3$ (d) $kx^4/32$ (e) $2kx^2/3$

24. An object of mass m moves horizontally, increasing in speed from 0 to v in time t. The constant power necessary to accelerate the object during this time period is

(a) $mv^2/(2t)$ (b) $v\sqrt{m/(2t)}$ (c) $2mv^2$ (d) $mv^2/2$ (e) $mv^2t/2$

25. A 55 kg skier is at the top of a slope, as shown in the figure. At the initial point A, the skier is $h = 10.0$m vertically above the final point B. Set the zero level for gravitational potential energy at A, write the gravitational potential energies of the skier at A and B, U_A and U_B respectively. (Take $g = 10$ m/s^2.)



(a) $5500\,J, 0\,J$ (b) $0\,J, -55\,J$ (c) $0\,J, -5500\,J$ (d) $0\,J, 5500\,J$ (e) $-5500\,J, 5500\,J$

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ATTENTION:Each question has only one correct answer and is worth one point. Be sure to fill in completely the circle that corresponds to your answer on the answer sheet. Use a pencil (not a pen). Only the answers on your answer sheet will be taken into account.

1. Which of the followings is/are true for any $\vec{A}$ and $\vec{B}$ vectors?

i. If these two vectors are perpendicular to each other, the magnitude of vector product is maximum value.
ii. If these two vectors are parallel to each other, scalar product gives the maximum value.
iii. The vector founded by the vector product of these vectors, is perpendicular to the plane constructed by these two vectors.

(a) i and ii (b) only i (c) All of them (d) i and iii (e) ii and iii

2. Which of the followings is/are always true for any $\vec{A}$, $\vec{B}$ and $\vec{C}$ vectors?

i. $\vec{A} \times (\vec{B} \times \vec{C}) = 0$
ii. $\vec{A} \times (\vec{B} \times \vec{A}) = 0$
iii. $\vec{A} \cdot (\vec{B} \times \vec{A}) = 0$

(a) All of them (b) None of them (c) Only i (d) Only iii (e) Only ii

Questions 3-5

The position of a mouse and the acceleration of a cat are given as functions of time as $\vec{r}_{\text{mouse}} = \text{A}t^2\ \hat{\imath} + \text{B}t\ \hat{\jmath}$ and $\vec{a}_{\text{cat}} = \text{C}\ \hat{\imath} + \text{D}t\ \hat{\jmath}$. The constants are A = 1 m/s^2, B = 2 m/s, C = 2/3 m/s^2, D = 2 m/s^3. The cat is initially at rest.

3. What is the velocity of the mouse in (m/s) at t = 2 s?
(a) $4\ \hat{\imath} + 2\ \hat{\jmath}$ (b) $8\ \hat{\imath} + 2\ \hat{\jmath}$ (c) $8\ \hat{\imath} + 8\ \hat{\jmath}$ (d) $2\ \hat{\imath} + 8\ \hat{\jmath}$ (e) $2\ \hat{\imath} + 2\ \hat{\jmath}$

4. What is the velocity of the mouse in (m/s) relative to the cat at t = 2 s?
(a) $2/3\ \hat{\imath} - 6\ \hat{\jmath}$ (b) $8/3\ \hat{\imath} - 6\ \hat{\jmath}$ (c) $-2/3\ \hat{\imath} + 6\ \hat{\jmath}$ (d) $8/3\ \hat{\imath} - 2\ \hat{\jmath}$ (e) $4\ \hat{\imath} - 2\ \hat{\jmath}$

5. The cat catches the mouse at the position $\vec{r} = 9\ (\text{m})\ \hat{\imath} + 6\ (\text{m})\ \hat{\jmath}$. Find the initial position of the cat in meters (m).
(a) $23/3\ \hat{\imath} - 2\ \hat{\jmath}$ (b) $8\ \hat{\imath} - 3\ \hat{\jmath}$ (c) $6\ \hat{\imath} - 3\ \hat{\jmath}$ (d) $19/3\ \hat{\imath} - 10\ \hat{\jmath}$ (e) $7\ \hat{\imath} - 10\ \hat{\jmath}$

Questions 6-10

A ball is thrown straight up in the air with an initial speed of 20 m/s. Ignore air resistance and take $g = 10\text{m/s}^2$.

6. What is the maximum height the ball can reach?
(a) 20 m (b) $5\sqrt{2}$ m (c) 5 m (d) 10 m (e) 400 m

7. What is the speed of the ball when it reaches 5 m above the ground?
(a) 5 m/s (b) $10\sqrt{3}$ m/s (c) 300 m/s (d) $5\sqrt{3}$ m/s (e) $10\sqrt{5}$ m/s

8. How long will it take for the ball to reach 5 m above its initial position on the way up?
(a) $(2+\sqrt{5})$ s (b) $(2-\sqrt{3})$ s (c) 2 s (d) $(5+\sqrt{2})$ s (e) $(5-\sqrt{2})$ s

9. How long will it take for the ball to reach 5 m above its initial position on the way down?
(a) 4 s (b) $2\sqrt{3}$ s (c) $(\sqrt{3}+2)$ s (d) $2\sqrt{5}$ s (e) $(\sqrt{3}-2)$ s

10. What will be its final speed just before it hits the ground?
(a) 20 m/s (b) 40 m/s (c) $40\sqrt{3}$ m/s (d) 5 m/s (e) 30 m/s

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11. A particle with mass m is moving on a vertical circle with radius R under an external force F that keeps the particle speed v constant during the motion. What is the total (net) work done on the particle in completing one full revolution?
(a) mv^2/R (b) $2\pi RF$ (c) $2mgR$ (d) $mv^2/2$ (e) 0

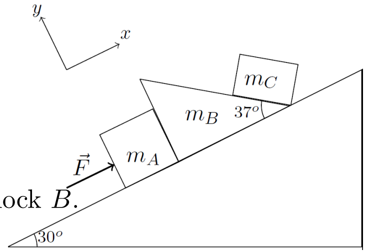
12. You can build a windmill on one of the two hills A and B. On hill A, the wind blows with a constant speed v for 24 hours every day. On hill B, the wind blows with a constant speed $2v$ for 12 hours every day. What would you expect for the relation of daily average work of mill A to mill B?
(a) Work A > Work B (b) Work B > Work A (c) There is no difference (d) It depends on the direction of the wind (e) The question can not be answered with available information

13. A father pulls his son, whose mass is m and who is sitting on a swing with ropes of length L, backward until the ropes make an angle of θ_0 with respect to the vertical. He then releases his son from rest. What is the speed of the son at the bottom of the swinging motion?

(a) $\sqrt{mgL\cos\theta_0}$ (b) $\sqrt{2gL\cos\theta_0}$ (c) $\sqrt{mgL(1-\cos\theta_0)}$ (d) $\sqrt{gL(1-\cos\theta_0)}$ (e) $\sqrt{2gL(1-\cos\theta_0)}$

Questions 14-16

Three blocks (A, B, C) on a frictionless inclined plane are in contact with each other as shown in the figure. Assume that there is no friction between the blocks. A force $\vec{F}$ parallel to the plane is applied to block A . The masses are $m_A = 5$ kg, $m_B = 2$ kg and $m_C = 1$ kg. Take $g = 10\text{m/s}^2$. ($\sin(37°) = 0.6$, $\cos(37°) = 0.8$, $\cos(30°) = 0.87$, $\sin(30°) = 0.5$)



14. What should be the magnitude of the force so that the objects remain motionless?

(a) 80 N (b) 35 N (c) 70 N (d) 40 N (e) 48 N

15. When the magnitude of the force is $36N$, find the acceleration of the blocks.

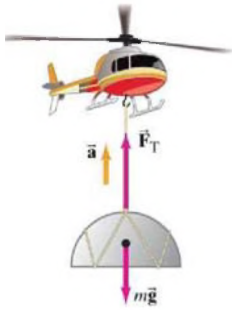
(a) 0.125 m/s^2 (b) -1.5 m/s^2 (c) -5.5 m/s^2 (d) -0.5 m/s^2 (e) -4.5 m/s^2

16. When the magnitude of the force is $36N$, find the magnitude of the force on block A due to block B.

(a) 16.5 N (b) 13.5 N (c) 8.5 N (d) 6.5 N (e) 15 N

Questions 17-19

A 7650-kg helicopter accelerates upward at 1.20 m/s^2 while lifting a 1250-kg frame at a construction site, shown in the figure at right. Take $g = 9.8$ m/s^2.



17. What is the lift force exerted by the air on the helicopter rotors?

(a) 9.80×10^3 N (b) 8.90×10^4 N (c) 9.87×10^4 N (d) 9.79×10^3 N (e) 9.79×10^4 N

18. What is the tension in the cable (ignore its mass) that connects the frame to the helicopter?

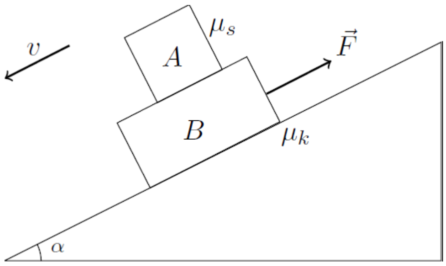
(a) 1.33×10^4 N (b) 1.375×10^3 N (c) 1.375×10^4 N (d) 1.25×10^3 N (e) 1.25×10^4 N

19. What force (and direction) does the cable exert on the helicopter?

(a) 1.25×10^3 N down (b) 1.375×10^4 N down (c) 1.33×10^4 N up (d) 1.25×10^4 N up (e) 1.375×10^4 N up

Questions 20-23

In order that two boxes, one on top of the other, are sliding down the ramp, together with the same constant speed, a force F is applied to the box B in the opposite direction of the motion, as shown in the figure. The coefficient of static friction between the two boxes is μ_s and the coefficient of kinetic friction between the box B and the ramp is μ_k. ($m_A = 1$ kg, $m_B = 9$ kg, $\mu_k = 0.5$, $\mu_s = 0.9$, $g = 10$ m/s^2, $\cos(30°) = 0.87$, $\sin(30°) = 0.5$)



20. Find the kinetic friction force if the angle is $\alpha = 30°$.

(a) 8 N (b) 10 N (c) 50 N (d) 43.5 N (e) 6.5 N

21. Find the force F if the angle is $\alpha = 30°$.

(a) 50 N (b) 8 N (c) 6.5 N (d) 15 N (e) 11 N

22. Find the static friction force between the two boxes if the angle is $\alpha = 30°$.

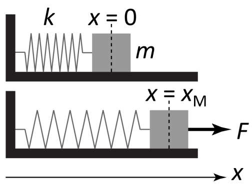
(a) 5 N (b) 45 N (c) 5.5 N (d) 2.4 N (e) 11 N

23. Find the maximum value of α such that the mass A does not move with respect to B.

(a) $\alpha_{max} = \tan^{-1}(\mu_s\cdot\mu_k)$ (b) $\alpha_{max} = \tan^{-1}(\mu_s/\mu_k)$ (c) $\alpha_{max} = \tan^{-1}(\mu_k^2/\mu_s)$
(d) $\alpha_{max} = \tan^{-1}(\mu_k)$ (e) $\alpha_{max} = \tan^{-1}(\mu_s)$

Questions 24-25

The block of mass m shown in the figure lies on a horizontal frictionless surface, and the spring constant is k. Initially, the spring is at its relaxed length and the block is stationary at position $x = 0$. Then an applied constant force F pulls the block in the positive x-direction, stretching the spring until the block stops at position $x = x_\mathrm{M}$.



24. What is the work done by the constant force F in the pulling process?

(a) 0 (b) kx_M^2 (c) $2F^2/k$ (d) $2kx_\mathrm{M}^2$ (e) F^2/k

25. In the pulling process, kinetic energy of the block constantly changes. What is the maximal value of kinetic energy the block will have as it moves from $x = 0$ to $x = x_\mathrm{M}$?

(a) $kx_\mathrm{M}^2/4$ (b) $kx_\mathrm{M}^2/2$ (c) $2F^2/k$ (d) mgx_M (e) $F^2/(2k)$

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ATTENTION:Each question has only one correct answer and is worth one point. Be sure to fill in completely the circle that corresponds to your answer on the answer sheet. Use a pencil (not a pen). Only the answers on your answer sheet will be taken into account.

1. Given $\vec{A} = \hat{\imath} + \hat{\jmath}$ and $\vec{B} = 2\,\hat{\imath} - 2\,\hat{k}$ vectors. Find the unit vector perpendicular to both $\vec{A}$ and $\vec{B}$ vectors.

(a) $\frac{-\hat{\imath}+\hat{\jmath}-\hat{k}}{\sqrt{3}}$ (b) $\frac{-4\,\hat{\imath}+\hat{\jmath}-2\,\hat{k}}{\sqrt{21}}$ (c) $\frac{-2\,\hat{\imath}+\hat{\jmath}-\hat{k}}{\sqrt{6}}$ (d) $\frac{-\hat{\imath}+5\,\hat{\jmath}-\hat{k}}{\sqrt{27}}$ (e) $\frac{-\hat{\imath}+\hat{\jmath}-\hat{k}}{\sqrt{6}}$

2. The position of a particle is given by $\vec{x} = 3t^2\ \hat{\imath}$ (m). What is the acceleration of the particle after 3 s?

(a) $9\,\mathrm{m/s^2}$ (b) $18\,\mathrm{m/s^2}$ (c) $0\,\mathrm{m/s^2}$ (d) $6\,\mathrm{m/s^2}$ (e) $3\,\mathrm{m/s^2}$

3. A block of mass m is sliding along a friction-free inclined plane with a slope angle of θ. The reaction force exerted by the plane on the block is

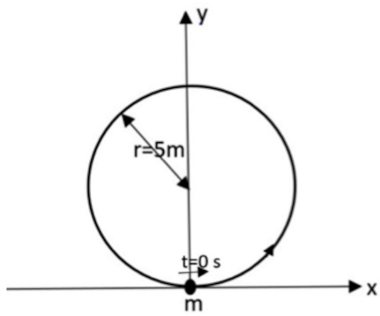
(a) mg (b) 0 (c) $mg\cos\theta\sin\theta$ (d) $mg\cos\theta$ (e) $mg\sin\theta$

4. The rocket starting its motion with speed 5 m/s on a straight way, moves for a 20 seconds with an acceleration of $a_t = 1+2t+3t^2$ ($\mathrm{m/s^2}$). Find the speed of the rocket at the end of 20 seconds.

(a) 8000 m/s (b) 8420 m/s (c) 8425 m/s (d) 1260 m/s (e) 8400 m/s

Questions 5-8

A particle of mass m moves in a circle of radius 5 m at constant speed taking time 40 s for each revolution (Period: T = 40 s). Particle passes from the origin (x = 0, y = 0) at time t = 0 s.



5. Find the displacement vector of the particle between 20 s and 30 s.

(a) 0 (b) $(-5\,\hat{\imath} - 5\,\hat{\jmath})$ m (c) $(-5\,\hat{\jmath})$ m (d) $(5\,\hat{\imath} - 5\,\hat{\jmath})$ m (e) $(5\,\hat{\imath} + 5\,\hat{\jmath})$ m

6. Find the average velocity of the particle between 20 s and 30 s.

(a) $\frac{1}{2}(\hat{\imath}-\hat{\jmath})$ m/s (b) $-\frac{1}{2}(\hat{\imath}+\hat{\jmath})$ m/s (c) $-\frac{1}{2}(\hat{\imath})$ m/s (d) 0 (e) $\frac{1}{2}(\hat{\imath}+\hat{\jmath})$ m/s

7. Find the average acceleration of the particle between 20 s and 30 s. (take $\pi = 3$)

(a) $\frac{3}{40}(\hat{\imath}-\hat{\jmath})\,\mathrm{m/s^2}$ (b) $\frac{3}{40}(\hat{\imath}+\hat{\jmath})\,\mathrm{m/s^2}$ (c) $\frac{3}{20}(\hat{\imath}-\hat{\jmath})\,\mathrm{m/s^2}$ (d) 0 (e) $9{,}8\,\hat{\jmath}\,\mathrm{m/s^2}$

8. Find the instant acceleration at 30 s. (take $\pi = 3$)

(a) $\frac{3}{80}(\hat{\imath}-\hat{\jmath})\,\mathrm{m/s^2}$ (b) $\frac{9}{80}(\hat{\imath}+\hat{\jmath})\,\mathrm{m/s^2}$ (c) $9{,}8\,\hat{\jmath}\,\mathrm{m/s^2}$ (d) $\frac{9}{80}(\hat{\imath})\,\mathrm{m/s^2}$ (e) $\frac{9}{80}(\hat{\jmath})\,\mathrm{m/s^2}$

9. A stock person at the local grocery store has a job consisting of the following five segments:

i. picking up boxes of tomatoes from the stockroom floor
ii. accelerating to a comfortable speed
iii. carrying the boxes to the tomato display at constant speed
iv. decelerating to a stop
v. lowering the boxes slowly to the floor.

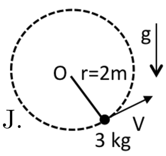
During which of the five segments of the job, does the stock person do positive work on the boxes?

(a) i, ii, iv and v (b) i only (c) i and ii (d) ii and iii (e) i and v

10. Two men, Joel and Jerry, push against a wall. Jerry stops after 10 min, while Joel is able to push for 5.0 min longer. Compare the work they do.

(a) Both men do positive work, but Joel does 25 % more work than Jerry.
(b) Both men do positive work, but Joel does 75 % more work than Jerry.
(c) Both men do positive work, but Jerry does 50 % more work than Joel.
(d) Neither of them does any work.
(e) Both men do positive work, but Joel does 50 % more work than Jerry.

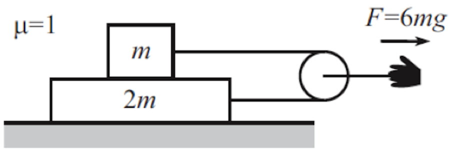
11. 3.00 kg ball swings rapidly in a complete vertical circle of radius 2.00 m by a light string that is fixed at one end. The ball moves so fast that the string is always straight and perpendicular to the velocity of the ball. As the ball swings from its lowest point to its highest point ($g=10\ \mathrm{m/s^2}$)



(a) the work done on it by gravity is +120 J and the work done on it by the tension in the string is -120 J.
(b) the work done on it by gravity is -120 J and the work done on it by the tension in the string is zero.
(c) the work done on it by gravity and the work done on it by the tension in the string are both equal to zero.
(d) the work done on it by gravity and the work done on it by the tension in the string are both equal to -120 J.
(e) the work done on it by gravity is -120J and the work done on it by the tension in the string is +120 J.

Questions 12-16

A block of mass m sits on top of a block of mass 2m which sits on a table. The coefficient of kinetic friction between all surfaces is $\mu = 1$. A massless string is connected to each mass and wraps halfway around a massless pulley, as shown. Assume that you pull on the pulley with a force of 6mg.



12. What is the magnitude of friction force between mass m and mass 2m?

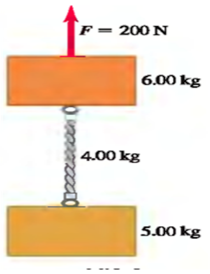
(a) 3mg (b) 4mg (c) mg (d) 2mg (e) 5mg

13. What is the magnitude of the friction force between ground and mass 2m?

(a) 3mg (b) 2mg (c) mg (d) 4mg (e) 5mg

14. What is the magnitude of the acceleration of mass m?

(a) 2g (b) g/2 (c) g/3 (d) g (e) 3g



15. What is the magnitude of the acceleration of mass 2m?

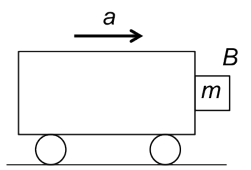
(a) g (b) 2g (c) g/2 (d) g/3 (e) 3g

16. What is the acceleration of your hand?

(a) g (b) g/2 (c) (5/3)g (d) (5/4)g (e) (5/2)g

17. The two blocks shown in figure are connected by a heavy uniform rope with a mass of 4.00 kg. An upward force of 200 N is applied as shown. What is the tension at the midpoint of the rope? (g = 10 m/s^2)

(a) 120 N (b) 45 N (c) 70 N (d) 93 N (e) 62 N



18. What is the minimum acceleration of mass m that is required to prevent block B from falling? Where the coefficient of static friction between the block and mass m is μ.

(a) $2g\mu$ (b) $g\mu/2$ (c) g/μ (d) $g\mu$ (e) $2g/\mu$

Questions 19-21

19. What work is done by a force $\vec{F} = (2.0x)\,\hat{\imath} - (3.0y^2)\,\hat{\jmath}$ (N), that moves a particle from a position $\vec{r_i} = 2.0\,\hat{\imath} + 3.0\,\hat{\jmath}$ (m) to a position $\vec{r_f} = -4.0\,\hat{\imath} - 3.0\,\hat{\jmath}$ (m), where $\vec{r}$, x and y are in meters? The mass of the particle is 2 kg.

(a) 66 J (b) 86 J (c) 76 J (d) 67 J (e) 42 J

20. If the initial velocity of the particle is 3.0 m/s, what is the final kinetic energy of the particle?

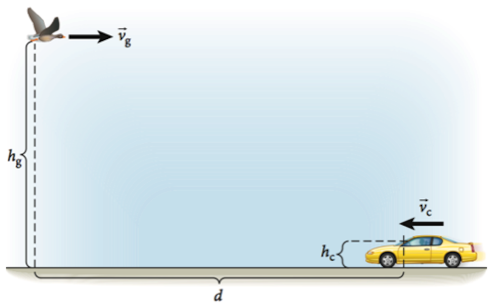
(a) 85 J (b) 79 J (c) 75 J (d) 81 J (e) 77 J

21. What is the magnitude of the acceleration of the particle at the position $\vec{r} = 2.0\,\hat{\imath} + 1.0\text{m}\,\hat{\jmath}$?

(a) 3.0 m/s^2 (b) 2.5 m/s^2 (c) 3.5 m/s^2 (d) 1.5 m/s^2 (e) 2.0 m/s^2

Questions 22-24

A speeding motorcyclist is traveling at a constant speed of 36 m/s when he passes a police car parked on the side of the road. At the instant the motorcycle passes the police car, the police officer starts to chase the motorcyclist with a constant acceleration of 4 m/s^2.



22. How long will it take the police officer to catch the motorcyclist?

(a) 36 s (b) 24 s (c) 18 s (d) 9 s (e) 27 s

23. What is the speed of the police car when it catches up to the motorcycle?

(a) 72 m/s (b) 108 m/s (c) 36 m/s (d) 144 m/s (e) 96 m/s

24. How far will the police car be from its original position when it catches up to the motorcycle?

(a) 1296 m (b) 648 m (c) 324 m (d) 162 m (e) 972 m

25. One goose is flying northward at a level altitude of h_g = 46 m above a north-south highway, when it sees a car ahead in the distance moving in the southbound lane and decides to deliver (drop) an "egg." The goose is flying at a speed of v_g = 15 m/s, and the car is moving at a speed of v_c = 97.2 km/h. The separation between the goose and the center of the front window of the car, is d = 126 m, at the instant when the goose takes action. (The center of the front window is h_c = 1.00 m off the ground.) When the "egg" strikes the front window, what is the relative velocity of the "egg" with respect to the car at the moment of the impact? (assume g = 10 m/s^2).

(a) $\vec{V} = 15\hat{\imath} - 30\hat{\jmath}$ m/s (b) $\vec{V} = 42\hat{\imath} - 25\hat{\jmath}$ m/s (c) $\vec{V} = 12\hat{\imath} - 30\hat{\jmath}$ m/s (d) $\vec{V} = 42\hat{\imath} - 30\hat{\jmath}$ m/s (e) $\vec{V} = 15\hat{\imath} + 30\hat{\jmath}$ m/s

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Questions 1-4

The position of a particle moving along the x-axis is given by $x(t) = 3 + Bt^3 - Ct^2$ where x is in meters and t is in seconds, B and C are constants.

1. What is the SI unit of the constant B?
(a) m^2/s^2 (b) m^2/s^3 (c) m/s^2 (d) m/s (e) m/s^3

2. If the particle comes to rest at $x = 24\ m$ when $t = 3\ s$, what are the numerical values of the constants B and C?
(a) $-12/7$ and 3 (b) 4 and -5 (c) $-14/9$ and -7 (d) 6 and 5 (e) $13/6$ and -3

3. When is the particle's acceleration zero?
(a) at 3.0 s (b) at 1.5 s (c) at 1.0 s (d) at 2.0 s (e) at 2.5 s

4. Which of the following is the average acceleration vector $\vec{a}_{av}$ between $t = 1\ s$ and $t = 3\ s$?
(a) $-8\hat{\imath}\ m/s^2$ (b) $-24/5\ \hat{\imath}\ m/s^2$ (c) $-14/3\ \hat{\imath}\ m/s^2$ (d) $8\hat{\imath}\ m/s^2$ (e) $25/4\ \hat{\imath}\ m/s^2$

Questions 5-7

A particle starts moving from the origin with an initial velocity $\vec{v}_0 = -8\hat{\jmath}\ m/s$ and its acceleration $\vec{a} = (4\hat{\imath}+2\hat{\jmath})\ m/s^2$.

5. What is the velocity of the particle as a function of time?
(a) $\vec{v}(t) = [(4t)\hat{\imath} + (3t)\hat{\jmath}]\ m/s$ (b) $\vec{v}(t) = [(2t)\hat{\imath} + (6t-8)\hat{\jmath}]\ m/s$ (c) $\vec{v}(t) = [(4t)\hat{\imath} + (2t-8)\hat{\jmath}]\ m/s$
(d) $\vec{v}(t) = [(3t)\hat{\imath} + (2t^2-8)\hat{\jmath}]\ m/s$ (e) $\vec{v}(t) = [(2t)\hat{\imath} + (4t-8)\hat{\jmath}]\ m/s$

6. When does the particle reach its minimum y-coordinate?
(a) $t = 6\ s$ (b) at $t = 4\ s$ (c) $t = 3\ s$ (d) $t = 5\ s$ (e) $t = 8\ s$

7. Assuming that there is a second particle moving with constant velocity $\vec{v}_2 = 2\hat{\imath} + 3\hat{\jmath}\ m/s$, what is the velocity of the *first particle relative to the second particle* at $t = 2\ s$?
(a) $-6\hat{\imath} + 7\hat{\jmath}\ m/s$ (b) $5\hat{\imath} - 4\hat{\jmath}\ m/s$ (c) $6\hat{\imath} - 7\hat{\jmath}\ m/s$ (d) $6\hat{\imath} - 8\hat{\jmath}\ m/s$ (e) $6\hat{\imath} + 6\hat{\jmath}\ m/s$

Questions 8-10

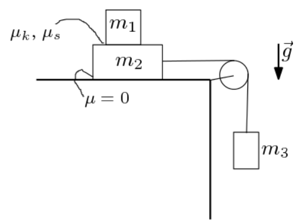
A particle is moving along the x-axis under the action of a variable force $\vec{F}(x) = (Cx - 3x^2)\hat{\imath}\ N$, where x is in meters and C is a constant. There is no friction.

8. What is the *dimension* of the constant C?
(a) $[ML/T^3]$ (b) $[ML/T^2]$ (c) $[M/T^3]$ (d) $[M/T^2]$ (e) $[ML^2/T^2]$

9. What is the work done by the force to move the particle from $x = 0$ to $x = 3\ m$?
(a) $(9C/2 + 24)\ J$ (b) $(7C/2 - 25)\ J$ (c) $(9C/2 - 27)\ J$ (d) $(9C/2 - 25)\ J$ (e) $(5C/2 + 27)\ J$

10. At $x = 0$, the particle's kinetic energy is 20 J and at $x = 3\ m$ it is 11 J. What is the numerical value of the constant C?
(a) 3 (b) 5 (c) 2 (d) 7 (e) 4

Questions 11-13



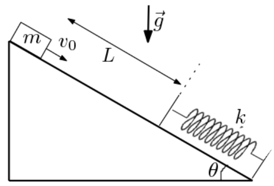
Consider the system shown in the figure: The coefficient of kinetic and static frictions between $m_1 = 2\ kg$ and $m_2 = 4\ kg$ are $\mu_k = 0.5$ and $\mu_s = 0.7$, respectively, and there is no friction between m_2 and the table. Take $g = 10\ m/s^2$.

11. If the blocks are moving in such a way that m_1 and m_2 are not sliding relative to each other (that is, they are moving as a single block), what is the magnitude of the force of friction between m_1 and m_2? Take $m_3 = 8\ kg$.
(a) $75/7\ N$ (b) $80/7\ N$ (c) $85/7\ N$ (d) $82/7\ N$ (e) $78/7\ N$

12. What is the **maximum** value of m_3 such that m_1 and m_2 does not slide relative to each other, that is, they move as a single object?
(a) 12 kg (b) 15 kg (c) 10 kg (d) 14 kg (e) 11 kg

13. If $m_3 = 21\ kg$, what are the accelerations of the blocks relative to the observer at rest on the table? (a_1 is the acceleration of m_1 and a_2 is the acceleration of m_2 and m_3.)
(a) $a_1 = 4\ m/^2$ and $a_2 = 15/2\ m/^2$ (b) $a_1 = 5\ m/^2$ and $a_2 = 8\ m/^2$ (c) $a_1 = 5\ m/^2$ and $a_2 = 17/2\ m/^2$ (d) $a_1 = 5\ m/^2$ and $a_2 = 7\ m/^2$ (e) $a_1 = 4\ m/^2$ and $a_2 = 10\ m/^2$

Questions 14-17



Consider the system shown in the figure: The coefficient of kinetic and static frictions between the block $m = 3\ kg$ and the inclined plane, of angle $\theta = 53^0$, are $\mu_k = 0.6$ and μ_s, respectively. The massles spring of force constant $k = 300\ N/m$ is fastened to the bottom of the inclined plane and it is initially unstretched. The block starts sliding down the incline with an initial speed v_0 and the initial distance between the block and the spring is $L = 70\ cm$. The amount of maximum compression of the spring by the block is $d = 30\ cm$. Take $g = 10\ m/s^2$. ($\sin 37 = \cos 53 = 3/5$ and $\cos 37 = \sin 53 = 4/5$.)

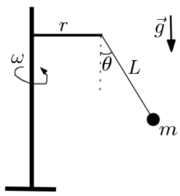
14. What is the *work done by the spring* until the block comes to rest at the maximum compression?
(a) $27/2\ J$ (b) $-27/2\ J$ (c) $-29/2\ J$ (d) $25/2\ J$ (e) $-25/2\ J$

15. What is the *work done by the friction* until the block comes to rest at the maximum compression?
(a) $-57/5\ J$ (b) $-59/5\ J$ (c) $-64/5\ J$ (d) $-51/5\ J$ (e) $-54/5\ J$

16. What is the value of v_0?
(a) $\sqrt{7}/5\ m/s$ (b) $\sqrt{3}/5\ m/s$ (c) $\sqrt{7}\ m/s$ (d) $\sqrt{5}/5\ m/s$ (e) $\sqrt{5}\ m/s$

17. What is **minimum** value of the μ_s such that the block can not rebound up the incline after the maximum compression?
(a) 11/4 (b) 12/5 (c) 13/3 (d) 11/3 (e) 13/6

Questions 18-20



A block of mass m is connected by a massless cord of length $L = 1\ m$ to a horizontal rod of length $r = 60\ cm$ which is being rotated about a vertical central shaft with a constant angular speed ω, as shown in the figure. Take $g = 10\ m/s^2$ and $\theta = 37^0$. ($\sin 37 = \cos 53 = 3/5$ and $\cos 37 = \sin 53 = 4/5$.)

18. What is the linear speed of the block m?
(a) $v = 2\ m/s$ (b) $v = 3\ m/s$ (c) $v = 3.5\ m/s$ (d) $v = 4.5\ m/s$ (e) $v = 4\ m/s$

19. What is angular speed ω of the rotating assembly?
(a) $\omega = 7/2\ rad/s$ (b) $\omega = 7\ rad/s$ (c) $\omega = 5/2\ rad/s$ (d) $\omega = 4\ rad/s$ (e) $\omega = 5\ rad/s$

20. If $m = 2\ kg$ and the maximum tension that the cord can stand without breaking is $T_{max} = 64\ N$, what is the maximum value that the ω can take without the cord breaks?
(a) $\omega_{max} = 5\ rad/s$ (b) $\omega_{max} = 3\ rad/s$ (c) $\omega_{max} = 8\ rad/s$ (d) $\omega_{max} = 6\ rad/s$ (e) $\omega_{max} = 4\ rad/s$

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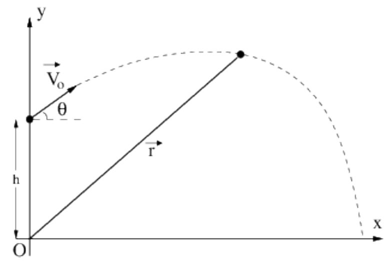
1. For what value of d is the vector $\vec{A} = 2\hat{\imath} + 2\hat{\jmath} + d\hat{k}$ perpendicular to the vector $\vec{B} = 4\hat{\imath} + 4\hat{\jmath} - 2\hat{k}$?
(a) 4 (b) 8 (c) -4 (d) -1 (e) 0

2. A particle is projected from y_0=h at t=0 with $\vec{V_0}$ velocity making an angle θ with the horizontal as shown in the figure. Take the magnitude of the gravitational acceleration as g. What is its maximum height of the object with respect to origin?
(a) $h + \frac{V_0^2 sin(2\theta)}{2g}$ (b) h (c) $\frac{V_0^2 sin(2\theta)}{2g}$ (d) $h + \frac{V_0^2 sin^2\theta}{2g}$ (e) $\frac{V_0^2 sin^2\theta}{2g}$



Questions 3-6

An object on a horizontal plane has an initial velocity $\vec{V_0} = 4.0\hat{\imath} + 1.0\hat{\jmath}$ (m/s) at a point where its position vector is $\vec{r_0} = 10\hat{\imath} - 4.0\hat{\jmath}$ (m) relative to an origin. The object moves with constant acceleration and after t=20 s, its velocity becomes $\vec{V} = 20\hat{\imath} - 5.0\hat{\jmath}$ (m/s).

3. What is the magnitude of its acceleration in m/s^2?
(a) -0.3 (b) 1.0 (c) $\sqrt{1.16}$ (d) 0.8 (e) $\sqrt{73}/10$

4. What is its position vector at $t = 2$ s?
(a) $18\hat{\imath} - 2\hat{\jmath}$ (b) $-18\hat{\imath} + 2\hat{\jmath}$ (c) $19.6\hat{\imath} - 2.6\hat{\jmath}$ (d) $9.6\hat{\imath} + 1.4\hat{\jmath}$ (e) $19.6\hat{\imath}$

5. What is the velocity of the object at $t = 2$ s?
(a) $0.6\hat{\imath} + 1.6\hat{\jmath}$ (b) $1.6\hat{\imath} - 0.6\hat{\jmath}$ (c) $1.6\hat{\imath} + 0.6\hat{\jmath}$ (d) $5.6\hat{\imath} + 2.6\hat{\jmath}$ (e) $5.6\hat{\imath} + 0.4\hat{\jmath}$

6. At what time, x coordinate of the object becomes zero?
(a) 2 s (b) 5 s (c) $\sqrt{5/2.2}$ s (d) never (e) ∞

Questions 7-10

In Fig, a 1.5 kg ball is connected by means of two massless strings, each of length L= 2.0 m, to a vertical, rotating rod. The strings are tied to the rod with separation d = 2.0 m and are taut. The tension in the upper string is 35 N.

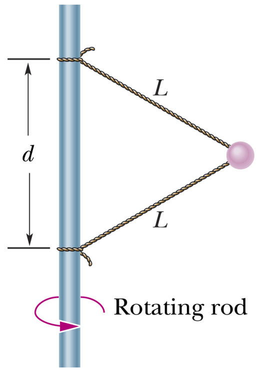
Take $g = 10$ m/s^2, $sin30 = 0.5$, $cos30 = 0.9$, $tan30 = 0.6$.

7. What is the tension in the lower string?
(a) 5.0 N (b) 16.4 N (c) 13.6 N (d) 18.3 N (e) 5.8 N

8. What is the magnitude of the net force on the ball?
(a) 36.0 N (b) 18.6 N (c) 26.6 N (d) 48.0 N (e) 54.6 N

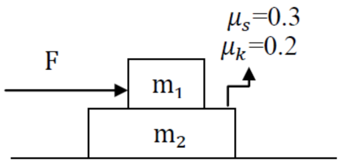
9. What is the speed of the ball?
(a) $\sqrt{14.2}$ m/s (b) $\sqrt{32.4}$ m/s (c) $\sqrt{24.3}$ m/s (d) $\sqrt{26.7}$ m/s (e) $\sqrt{40.0}$ m/s

10. What is the direction of the net force on the ball?
(a) downward (b) radially towards the rod (c) upward (d) none of these (e) radially away from the rod



Questions 11-14

Two blocks of masses $m_1 = 4$ kg and $m_2 = 6$ kg are standing one on the top of the other, as shown in the figure. The coefficients of static and kinetic friction between the blocks are $\mu_s = 0.3$ and $\mu_k = 0.2$ respectively. The surface between m_2 and the floor is frictionless. A horizontal force F is applied on the m_1 as shown in the figure. ($g = 10$ m/s^2)



11. What is the maximum value for F so that m_1 and m_2 move together, without m_1 sliding on the surface of m_2?

(a) 50 N (b) 40 N (c) 15 N (d) 20 N (e) 25 N

12. If $F = 16$ N, what are the accelerations a_1 and a_2 for m_1 and m_2, respectively?

(a) $a_1 = a_2 = 1.6$ m/s^2 (b) $a_1 = a_2 = 1$ m/s^2 (c) $a_1 = a_2 = 2$ m/s^2 (d) $a_1 = a_2 = 0.16$ m/s^2 (e) $a_1 = a_2 = 3.2$ m/s^2

13. If $F = 16$ N, what is the magnitude of the static frictional force?

(a) 10 N (b) 16 N (c) 20 N (d) 30 N (e) 48/5 N

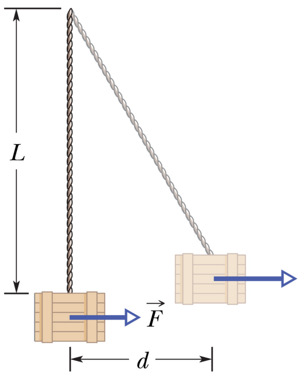
14. If $F = 24$ N, what are the accelerations a_1 and a_2?

(a) $a_1 = 10$ m/s^2 ; $a_2 = 4/3$ m/s^2
(b) $a_1 = 4$ m/s^2 ; $a_2 = 10/3$ m/s^2
(c) $a_1 = 4$ m/s^2 ; $a_2 = 4/3$ m/s^2
(d) $a_1 = 2$ m/s^2 ; $a_2 = 2/3$ m/s^2
(e) $a_1 = 5$ m/s^2 ; $a_2 = 5/3$ m/s^2

Questions 15-17

A 280 kg crate hangs from the end of a rope of length $L = 15.0$ m. You push the crate horizontally with a varying force F to move it a distance of $d = 5.0$ m to the side. The crate is at rest before and after its displacement.

Take $g = 10$ m/s^2, $\sqrt{2} = 1.4$.



15. What is the magnitude of F when the crate is in this final position?

(a) 1000 N (b) 1200 N (c) 7840 N (d) 800 N (e) 2640 N

16. During the crate's displacement, what is the work done by the gravitational force on the crate?

(a) 1400 J (b) 2800 J (c) −1400 J (d) 0 J (e) −2800 J

17. What is the work done on the crate by the tension in the rope?

(a) 1400 J (b) −1400 J (c) −2800 J (d) 0 J (e) 2800 J

Questions 18-20

A net force $\vec{F} = (Ax - 6x^2)\hat{\imath}$ acts on a particle as the particle moves along the x-axis, with $\vec{F}$ in newtons, x in meters, and A a constant.

18. What is the SI unit of the constant A?

(a) N/m^2 (b) N·m (c) N/m (d) N (e) N·m^2

19. What is the work done in moving the particle from the origin, $x = 0$ to $x = 2$ m?

(a) $3A - 27$ (b) $2A - 16$ (c) $4A + 27$ (d) $10A + 27$ (e) $9A - 27$

20. At $x = 0$, the particle's kinetic energy is 12 J; at $x = 2$ m, it is 32 J. What is the value of the constant A?

(a) −16 (b) 18 (c) −12 (d) 2 (e) 6

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Questions 1-5

An object of mass m is thrown from point A at $t = 0$ with an initial speed $v_0 = 10\ m/s$ from a height $h = 1\ m$ over the ground making an angle $\theta = 53^o$ with the horizontal, and following the trajectory shown in the figure, it hits the point D which is at height $H = 7/4\ m$ over the ground.

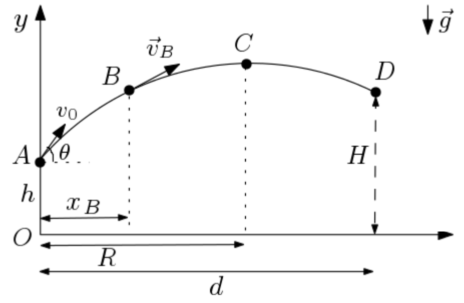
Take $g = 10\ m/s^2$ **and** $\sin 53^o = \cos 37^o = 4/5$ **.**

1. In the given Cartesian coordinate system, which of the followings is the $y(t)$ of the object in meters?

(a) $1 + 8t + 5t^2$ (b) $1 + 6t - 5t^2$ (c) $1 - 8t - 5t^2$ (d) $1 + 8t - 5t^2$ (e) $1 - 6t + 5t^2$

2. What is the time to reach point D in seconds?

(a) 2 (b) 5/3 (c) 4/3 (d) 1 (e) 3/2



3. If C is the highest point of the trajectory over the ground, what is the ratio R/d?

(a) 4/5 (b) 3/5 (c) 7/15 (d) 8/15 (e) 11/15

4. Assuming that B and D are at the same height, what is x_B in meters?

(a) 3/5 (b) 4/3 (c) 2/5 (d) 1 (e) 3/4

5. What is the velocity $\vec{v}_B$ at point B in units of m/s?

(a) $6\hat{\imath} - 6\hat{\jmath}$ (b) $6\hat{\imath} + 7\hat{\jmath}$ (c) $8\hat{\imath} + 7\hat{\jmath}$ (d) $6\hat{\imath} - 7\hat{\jmath}$ (e) $8\hat{\imath} + 6\hat{\jmath}$

Questions 6-8

Consider a particle moving in the xy-plane with a constant acceleration. At $t = 0$ the particle's initial position is $(2\ m)\hat{\imath} - (3\ \mathrm{m})\hat{\jmath}$ and at that instant its initial velocity is $(10\ m/s)\hat{\imath}$. At $t = 3\ s$ its velocity is $(4\ m/s)\hat{\imath} + (3\ \mathrm{m/s})\hat{\jmath}$.

6. What is the acceleration of this particle?

(a) $(2\ m/s^2)\hat{\imath} - (1\ \mathrm{m/s^2})\hat{\jmath}$ (b) $(3\ m/s^2)\hat{\imath} + (2\ \mathrm{m/s^2})\hat{\jmath}$ (c) $(-2\ m/s^2)\hat{\imath} + (3\ \mathrm{m/s^2})\hat{\jmath}$ (d) $(-3\ m/s^2)\hat{\imath} + (2\ \mathrm{m/s^2})\hat{\jmath}$
(e) $(-2\ m/s^2)\hat{\imath} + (1\ \mathrm{m/s^2})\hat{\jmath}$

7. What is the position vector of the particle at $t = 3\ s$?

(a) $(5\ m)\hat{\imath} + (2\ \mathrm{m})\hat{\jmath}$ (b) $(17\ m)\hat{\imath} + (5/2\ \mathrm{m})\hat{\jmath}$ (c) $(23\ m)\hat{\imath} + (3/2\ \mathrm{m})\hat{\jmath}$ (d) $(13\ m)\hat{\imath} + (5/2\ \mathrm{m})\hat{\jmath}$
(e) $(3\ m)\hat{\imath} + (4\ \mathrm{m})\hat{\jmath}$

8. During the time interval $t_i = 0$ and $t_f = 3\ s$ what is the average velocity of the particle?

(a) $(4\ m)\hat{\imath} + (5/2\ \mathrm{m})\hat{\jmath}$ (b) $(7\ m)\hat{\imath} + (3/2\ \mathrm{m})\hat{\jmath}$ (c) $(5\ m)\hat{\imath} + (5/2\ \mathrm{m})\hat{\jmath}$ (d) $(4\ m)\hat{\imath} + (7/2\ \mathrm{m})\hat{\jmath}$ (e) $(5\ m)\hat{\imath} + (3\ \mathrm{m})\hat{\jmath}$

Questions 9-10

A block of mass m is at rest at the origin at $t = 0$. It is pushed with constant force F_0 from $x = 0$ to $x = L$ across a horizontal surface whose coefficient of kinetic friction is $\mu_k = \mu_0(1 - x/L)$, that is, the coefficient of friction decreases from μ_0 at $x = 0$ to zero at $x = L$.

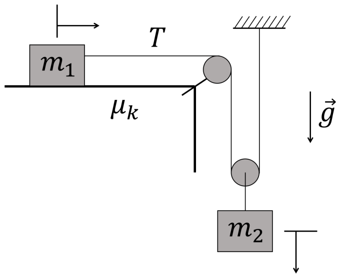
9. What is the net work done by the net force to bring the block from $x = 0$ to $x = L$?

(a) $\left(F_0 - \frac{3}{2}mg\mu_0\right)L$ (b) $\left(2F_0 - \frac{1}{2}mg\mu_0\right)L$ (c) $\left(F_0 + \frac{3}{2}mg\mu_0\right)L$ (d) $\left(3F_0 + \frac{5}{2}mg\mu_0\right)L$ (e) $\left(F_0 - \frac{1}{2}mg\mu_0\right)L$

10. What is the block's speed as it reaches position L?

(a) $\sqrt{\left(\frac{F_0}{m} - 4\mu_0 g\right)L}$ (b) $\sqrt{\left(\frac{F_0}{m} - 3\mu_0 g\right)L}$ (c) $\sqrt{\left(\frac{2F_0}{m} + 3\mu_0 g\right)L}$ (d) $\sqrt{\left(\frac{2F_0}{m} - 3\mu_0 g\right)L}$ (e) $\sqrt{\left(\frac{2F_0}{m} - \mu_0 g\right)L}$

Questions 11-13



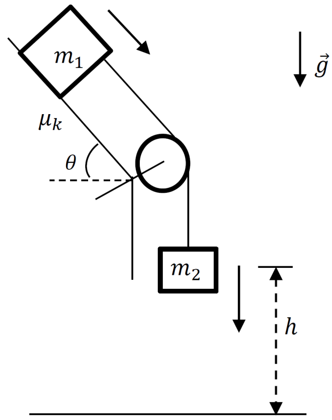
Consider the system shown in the figure. The pulleys are assumed to be frictionless and massless. The coefficient of kinetic friction between m_1 and the horizontal surface is $\mu_k = 0.25$. Take $m_1 = 2\ kg$ and $m_2 = 4\ kg$, $g = 10\ m/s^2$.

11. What is the relation between the manitudes of the accelerations of the blocks?
(a) $3a_1 = 2a_2$ (b) $a_1 = a_2$ (c) $a_1 = 3a_2$ (d) $a_1 = 2a_2$ (e) $2a_1 = a_2$

12. What is the acceleration of the block m_1?
(a) $3\ m/s^2$ (b) $4.5\ m/s^2$ (c) $3.5\ m/s^2$ (d) $5\ m/s^2$ (e) $4\ m/s^2$

13. What is the tension T in the rope?
(a) $13\ N$ (b) $11\ N$ (c) $19\ N$ (d) $17\ N$ (e) $15\ N$

Questions 14-16



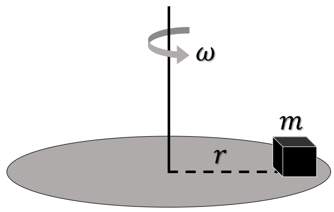
Two blocks of masses $m_1 = 5\ kg$ and $m_2 = 10\ kg$ are connected by a string of negligible mass, as shown in the figure. The coefficient of kinetic friction between the block m_1 and the inclined plane is given by $\mu_k = 0.25$ and the angle of inclanation is $\theta = 37^o$.
Take $g = 10\ m/s^2$ **and** $\sin 37^o = \cos 53^o = 3/5$ **.**

14. What is the acceleration of the blocks?
(a) $6.5\ m/s^2$ (b) $8\ m/s^2$ (c) $6\ m/s^2$ (d) $7\ m/s^2$ (e) $7.5\ m/s^2$

15. What is the tension in the string?
(a) $25\ N$ (b) $30\ N$ (c) $15\ N$ (d) $35\ N$ (e) $20\ N$

16. What is the work done by gravity when m_2 falls a distance $h = 0.5\ m$?
(a) $55\ J$ (b) $65\ J$ (c) $60\ J$ (d) $50\ J$ (e) $45\ J$

Questions 17-18

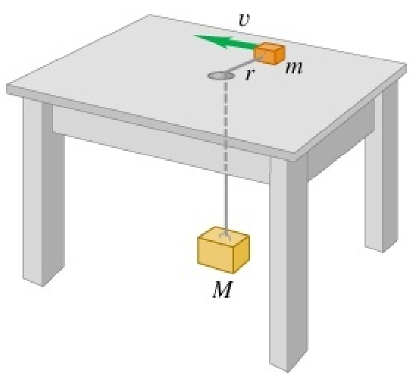


A disk shaped platform of radius R is being rotated with a constant angular speed $\omega = 3\ rad/s$ about the axis passing through its center of mass, as shown in the figure. A block of mass $m = 500\ g$ is at rest relative to the platform at a distance $r = 25\ cm$ from the axis of rotation. The coefficient of static and kinetic frictions between the block and the platform are $\mu_s = 0.7$ and $\mu_k = 0.4$, respectively.
Take $g = 10\ m/s^2$.

17. What is the magnitude and direction of the friction force on m?
(a) $11/8\ N$, away from the rotation axis
(b) $9/5\ N$, towards the rotation axis
(c) $9/8\ N$, towards the rotation axis
(d) $11/8\ N$, towards the rotation axis
(e) $9/8\ N$, away from the rotation axis

18. What is the maximum value of ω to keep the block at rest relative to the platform in units of rad/s?
(a) $3\sqrt{7}$ (b) $2\sqrt{7}$ (c) $4\sqrt{2}$ (d) $3\sqrt{5}$ (e) $2\sqrt{5}$

Questions 19-20



A small block of mass $m = 0.5\ kg$ is set into a uniform circular motion on a horizontal frictionless table at a distance $r = 50\ cm$ from a hole in the center of the table, as shown in the figure. A string tied to m passes down through the hole, and a larger block of mass M is suspended from the free end of the string. If the small block m makes 4 turns in a second, the height of M is not changing.
Take $g = 10\ m/s^2$, $\pi \approx 3$.

19. For this given configuration of the system, what is the magnitude of the acceleration of m?
(a) $328\ m/s^2$ (b) $148\ m/s^2$ (c) $288\ m/s^2$ (d) $178\ m/s^2$ (e) $258\ m/s^2$

20. What is the value of M?
(a) $72/5\ kg$ (b) $18\ kg$ (c) $17\ kg$ (d) $76/7\ kg$ (e) $72/7\ kg$

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For all questions take $\frac{1}{4\pi\epsilon_o} = 9 \times 10^9 \ N\,m^2/C^2$.

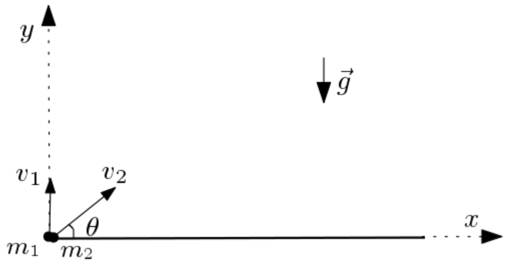
1. Which of the following is a unit vector perpendicular to both $\vec{A} = 2\hat{\imath} + \hat{\jmath}$ and $\vec{B} = 3\hat{\imath} - 2\hat{k}$?

(a) $\frac{3\hat{\imath}+2\hat{\jmath}-3\hat{k}}{\sqrt{29}}$ (b) $\frac{-3\hat{\imath}+4\hat{\jmath}-2\hat{k}}{\sqrt{29}}$ (c) $\frac{3\hat{\imath}+4\hat{\jmath}-3\hat{k}}{\sqrt{34}}$ (d) $\frac{-3\hat{\imath}+4\hat{\jmath}+3\hat{k}}{\sqrt{34}}$ (e) $\frac{-2\hat{\imath}+4\hat{\jmath}-3\hat{k}}{\sqrt{29}}$

Questions 2-4

An object of mass m_1 and another object of mass m_2 are thrown at the same instant from the ground with the same initial speeds $v_1 = v_2 = 5\ m/s$, as shown in the figure. $\theta = 53^o$ and take $g = 10\ m/s^2$.

Take $g = 10\ m/s^2$ **and** $\theta = 53^o$ **,** $\sin 53^o = 4/5$ **.**



2. What is the acceleration vector of m_1 relative to m_2?

(a) 0 (b) $\frac{1}{2}g\hat{\jmath}$ (c) $-\frac{1}{2}g\hat{\jmath}$ (d) $-g\hat{\jmath}$ (e) $g\hat{\jmath}$

3. What is the velocity of m_1 relative to m_2 when m_2 is at the heighest point of its trajectory in units of m/s?

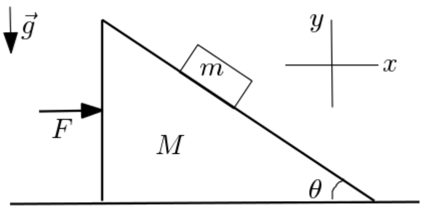
(a) $-2\hat{\imath} + \hat{\jmath}$ (b) $3\hat{\imath} - 2\hat{\jmath}$ (c) $\hat{\imath} + \hat{\jmath}$ (d) $\hat{\imath} - \hat{\jmath}$ (e) $-3\hat{\imath} + \hat{\jmath}$

4. What is the distance between m_1 and m_2 at $t = 0.5\ s$?

(a) $\sqrt{2}\ m$ (b) $3/2\ m$ (c) $\sqrt{10}/2\ m$ (d) $\sqrt{3}\ m$ (e) $\sqrt{7}/2\ m$

Questions 5-8

A constant horizontal force $F = 32\ N$ is applied on $M = 4\ kg$ and the system is moving to the right, as shown in the figure. The small block $m = 2\ kg$ is at rest relative to M during the motion. There is no friction between M and the ground, the coefficient of static friction between m and M is $\mu_s = 0.5$, and the angle of inclanation is $\theta = 53^o$. (Take $g = 10\ m/s^2$ and $\sin 53 = 4/5$.)



5. What is the acceleration of the system?

(a) $16/3\ m/s^2$ (b) $3\ m/s^2$ (c) $4\ m/s^2$ (d) $5\ m/s^2$ (e) $14/3\ m/s^2$

6. What is the magnitude of the normal force applied on m by M?

(a) $20\ N$ (b) $308/15\ N$ (c) $298/15\ N$ (d) $17\ N$ (e) $21\ N$

7. What is the magnitude of the friction force between m and M?

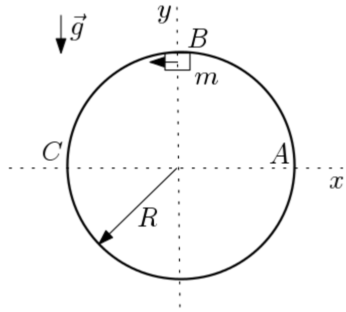
(a) $154/15\ N$ (b) $157/15\ N$ (c) $14\ N$ (d) $48/5\ N$ (e) $51/5\ N$

8. What is the minimum value of F which keeps m at rest relative to M during the motion of the system?

(a) $30\ N$ (b) $25\ N$ (c) $28\ N$ (d) $19\ N$ (e) $22\ N$

Questions 9-12

A small remote-controlled car of mass $m = 500\ g$ is moving at a constant speed $v = 6\ m/s$ in a vertical circle of radius $R = 1.5\ m$ inside a hollow metal cylinder. The object is at point A at time $t = 0$. (Take $g = 10\ m/s^2$.)



9. What is the normal force exerted on the car by the walls of the cylinder at point B?

(a) $12\ N$ (b) $11\ N$ (c) $7\ N$ (d) $5\ N$ (e) $14\ N$

10. What is the normal force exerted on the car by the walls of the cylinder at point C?

(a) $11\ N$ (b) $12\ N$ (c) $14\ N$ (d) $5\ N$ (e) $7\ N$

11. What is the average velocity of the car between $t = 0$ and $t = \pi/4\ s$ in units of m/s?

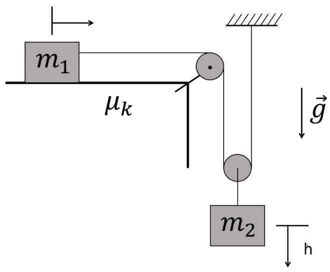
(a) $+\frac{10}{\pi}\hat{j}$ (b) $-\frac{12}{\pi}\hat{i}$ (c) $+\frac{12}{\pi}\hat{i}$ (d) $-\frac{12}{\pi}\hat{j}$ (e) $-\frac{10}{\pi}\hat{i}$

12. What is the average acceleration vector of the car between $t = 0$ and $t = \pi/4\ s$ in units of m/s^2?

(a) $-\frac{44}{\pi}\hat{j}$ (b) $+\frac{44}{\pi}\hat{i}$ (c) $+\frac{48}{\pi}\hat{i}$ (d) $-\frac{48}{\pi}\hat{j}$ (e) $-\frac{48}{\pi}\hat{i}$

Questions 13-16

The system shown in the figure starts motion from rest. The coefficient of kinetic friction between $m_1 = 1\ kg$ and the table is $\mu_k = 0.2$. Assume that the cords and the pulleys are massless. The acceleration of m_1 is a_1 and that of $m_2 = 2\ kg$ is a_2.



13. What is the relation between the accelerations of the blocks?

(a) $a_1 = 3a_2$ (b) $3a_1 = a_2$ (c) $2a_1 = a_2$ (d) $a_1 = 2a_2$ (e) $a_1 = a_2$

14. What is the tension in the rope tied to m_1?

(a) $7\ N$ (b) $22/3\ N$ (c) $21/4\ N$ (d) $21/5\ N$ (e) $8\ N$

15. What is the work done by friction when m_2 falls a distance $h = 50\ cm$?

(a) $-6\ J$ (b) $-5\ J$ (c) $-4\ J$ (d) $-2\ J$ (e) $-3\ J$

16. What is the speed of m_2 when it falls a distance $h = 50\ cm$?

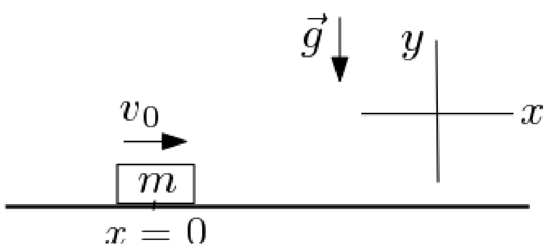
(a) $\frac{3\sqrt{2}}{3}\ m/s$ (b) $\frac{5\sqrt{3}}{3}\ m/s$ (c) $\frac{4\sqrt{2}}{3}\ m/s$ (d) $\frac{2\sqrt{3}}{3}\ m/s$ (e) $\frac{2\sqrt{6}}{3}\ m/s$

Questions 17-20

A block of mass m with initial speed v_0 enters into a region of a rough surface at $x = 0$, as shown in the figure. The coefficient of kinetic friction in this region is variable and of the form $\mu_k = bx$, where b is a constant.

17. What is the SI unit of the constant b?

(a) m (b) m/s (c) m^{-1} (d) m^{-2} (e) $m \cdot s$



18. What is the magnitude of the acceleration of the block as a function of x?

(a) $3bx$ (b) bgx (c) gx (d) $2bx$ (e) $2gx$

19. Which of the following is the work done by the friction between $x = 0$ and $x = d$?

(a) $-bmgd$ (b) $-\frac{3}{2}bmgd^2$ (c) $-\frac{3}{2}bmgd$ (d) $-\frac{1}{2}bmgd$ (e) $-\frac{1}{2}bmgd^2$

20. At which point x the block comes to rest?

(a) $\frac{3v_0}{\sqrt{g}}$ (b) $\frac{v_0}{\sqrt{bg}}$ (c) $\frac{2v_0}{\sqrt{g}}$ (d) $\frac{2v_0}{\sqrt{mg}}$ (e) $\frac{v_0}{\sqrt{b^2 g}}$

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ATTENTION: There is normally only one correct answer for each question and each correct answer is equal to 1 point. Only the answers on your answer sheet form will be evaluated. Please be sure that you have marked all of your answers on the answer sheet form by using a pencil (*not* pen).

Questions 1-5

1. If ρ has a units of kg/m^3, and P has units of N/m^2, what are the units of c if $c = \sqrt{5P/3\rho}$?

(a) m^3/s (b) m/s (c) $m^2/s^{1/2}$ (d) kgm^2/s^2 (e) $s^{1/2}$

2. Drag force of the air is given by the equation $D = bv^2$ where $b = 4.0Ns^2/m^2$ and v is the speed of the object. An object of mass $m = 10.0kg$ is falling under the effect of constant gravity and this drag force to the ground. What is the terminal speed (the constant speed) of the object? ($g = 10\,m/s^2$)

(a) $3.0m/s$ (b) $4.0m/s$ (c) $6.0m/s$ (d) $5.0m/s$ (e) $5.5m/s$

3. Vector $\vec{a} = 2\hat{\imath} + 3\hat{\jmath} - 5\hat{k}$ and vector $\vec{b} = \hat{\imath} - 2\hat{\jmath} - 3\hat{k}$ are given. Find a vector $\vec{c}$ that is perpendicular to both $\vec{a}$ and $\vec{b}$.

(a) $\vec{c} = -19\hat{\imath} + \hat{\jmath} + 7\hat{k}$ (b) $\vec{c} = +19\hat{\imath} + \hat{\jmath} - 7\hat{k}$ (c) $\vec{c} = -19\hat{\imath} + \hat{\jmath} - 7\hat{k}$ (d) $\vec{c} = 19\hat{\imath} + \hat{\jmath} + 7\hat{k}$ (e) $\vec{c} = -19\hat{\imath} - \hat{\jmath} - 7\hat{k}$

4. Vectors $\vec{A} = 4\hat{\imath} + a\hat{\jmath} + 2\hat{k}$ and $\vec{B} = -3\hat{\imath} + 2\hat{\jmath} + b\hat{k}$ are given. Find the value of $a + b$ if the angle between these two vectors is 90^o.

(a) 12 (b) 8 (c) 6 (d) 7 (e) 5

5. The period of an object making uniform circular motion on a circular trajectory of radius R is T. What is the magnitude of the centripetal acceleration?

(a) $\dfrac{4\pi^2R^2}{T^3}$ (b) $\dfrac{4\pi^2R}{T}$ (c) $\dfrac{2\pi^2R^2}{T^3}$ (d) $\dfrac{\pi^2R}{T^2}$ (e) $\dfrac{4\pi^2R}{T^2}$

Questions 6-7

While driving along a highway at 40 m/s you see a police car 50 m ahead traveling at a constant speed of 30 m/s which is the speed limit. You apply the brakes and begin decelareting at 1.0 m/s^2.

6. After applying to the brakes, when will you reach to the police car?

(a) $10s$ (b) $14s$ (c) $8.0s$ (d) $12s$ (e) $9.0s$

7. After applying to the brakes, what is the distance covered by the car to reach the police car?

(a) $300m$ (b) $450m$ (c) $250m$ (d) $350m$ (e) $400m$

Questions 8-10

A particle starts from the origin at $t = 0$ with a velocity of $4.0\hat{\jmath}$ and moves in the xy plane with a constant acceleration of $(2.0\hat{\imath} - 3.0\hat{\jmath})m/s^2$.

8. At $t = 2.0s$, what is the distance of the particle to the origin?

(a) $2\sqrt{5}m$ (b) $4.0m$ (c) $4\sqrt{5}$ (d) $3\sqrt{3}$ (e) $5.0m$

9. Find the velocity of the particle at $t = 2.0s$ in units of m/s.

(a) $3.0\hat{\imath} - 2.0\hat{\jmath}$ (b) $-4.0\hat{\imath} - 2.0\hat{\jmath}$ (c) $4.0\hat{\imath} - 2.0\hat{\jmath}$ (d) $4.0\hat{\imath} + 2.0\hat{\jmath}$ (e) $-3.0\hat{\imath} + 2.0\hat{\jmath}$

10. A second object is moving with a velocity $\vec{v} = -2\hat{\imath} + \hat{\jmath}$ m/s in this coordinate system. What is the velocity of this object with respect to the first at $t = 2$ s in units of m/s?

(a) $-4.0\hat{\imath} + 3.0\hat{\jmath}$ (b) $-4.0\hat{\imath} + 5.0\hat{\jmath}$ (c) $6.0\hat{\imath} - 3.0\hat{\jmath}$ (d) $-6.0\hat{\imath} + 3.0\hat{\jmath}$ (e) $4.0\hat{\imath} - 3.0\hat{\jmath}$

11. A 5.0 kg mass is suspended by a string from the ceiling of an elevator that is moving upward with a speed which is decreasing at a constant rate of 2.0 m/s in each second. What is the tension in the string supporting the mass assuming that $g = 10m/s^2$?

(a) 40 N (b) 60 N (c) 15 N (d) 45 N (e) 50 N

12. Consider a horizontal block-spring system such that the block is released from rest when the spring is stretched a distance d. The spring obeys the Hooke's Law. If the spring constant $k = 50$ N/m, the mass of the block is $m = 0.50$ kg, $d = 10$ cm, and the coefficient of kinetic friction $\mu_k = 0.25$, what is the speed of the block when it first passes through the position for which the spring is unstretched ? ($g = 10m/s^2$)

(a) $\frac{\sqrt{3}}{2}$ m/s (b) $\sqrt{\frac{3}{2}}$ m/s (c) $\frac{1}{\sqrt{3}}$ m/s (d) $\frac{\sqrt{2}}{2}$ m/s (e) $\frac{1}{2}$ m/s

Questions 13-15

A box of mass m is sitting on top of another box of mass M, which sits on a frictionless layer of ice. There is friction between the two boxes. A horizontal force of magnitude F is applied to the lower box

13. Assume that the static friction is such that the two boxes will move together. What is the acceleration of the system?

(a) $\frac{Fm}{M^2}$ (b) $\frac{F}{m}$ (c) $\frac{F}{M}$ (d) $\frac{F(m+M)}{mM}$ (e) $\frac{F}{m+M}$

14. What is the minimum coefficient of static friction μ_s between the two boxes such that they move together?

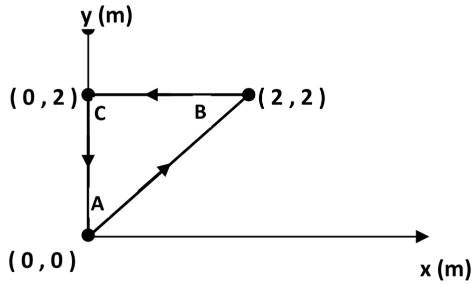
(a) $\frac{F}{g(m+M)}$ (b) $\frac{F}{gM}$ (c) $\frac{F(m+M)}{gmM}$ (d) $\frac{F}{gm}$ (e) $\frac{Fm}{gM^2}$

15. Now, assume that something is exerting an additional vertical downwards force F_2 on the upper box. What would the minimum μ_s now be such that the two boxes still move together?

(a) $\frac{MF_2}{m(m+M)(mg+F_2)}$ (b) $\frac{mF}{M(m+M)(mg+F)}$ (c) $\frac{mF}{M(m+M)(mg+F_2)}$ (d) $\frac{MF_2}{(m+M)(mg+F)}$ (e) $\frac{mF}{(m+M)(mg+F_2)}$

Questions 16-18

A force acting on a particle is given by $F = (3\hat{i} + 4x\hat{j})N$.



16. Calculate W_{AB}, the work done by the force to take the particle from $(0,0)$ to $(2,2)$.

(a) 16J (b) 10J (c) 14J (d) 8J (e) 12J

17. Calculate W_{BC}, the work done by the force to take the particle from $(2,2)$ to $(0,2)$.

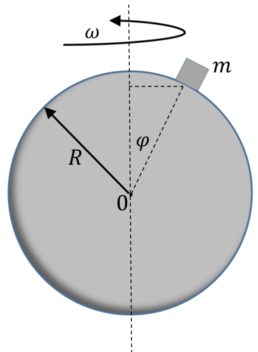
(a) 0J (b) −6J (c) 6J (d) 4J (e) −4J

18. Calculate W_{TOT}, the total work done for the complete loop.

(a) 6J (b) 8J (c) 4J (d) 2J (e) 0J

Questions 19-20

A small mass m is put on the surface of the sphere of radius R, as shown in the figure. The coefficient of static friction between the mass and the surface is μ_s. Answer the following questions, expressing your answers in terms of $\{R, m, \varphi, g, \mu_s\}$.



19. Initially the sphere and the mass are at rest. Find the minimum value of μ_s so that the mass does not slide on the sphere because of friction?

(a) φ (b) $\tan\varphi$ (c) $\cos\varphi$ (d) $\sin\varphi$ (e) $\cot\varphi$

20. If the sphere is rotating about its axis with a constant angular speed ω, as shown in the figure, what is the maximum value of ω such that the mass m is at rest? ($v = \omega r$)

(a) $\omega = \sqrt{\frac{g}{R}}$

(b) $\omega = \sqrt{\frac{g}{R}\left(\frac{\cos\varphi - \mu_s \sin\varphi}{\mu_s \sin^2\varphi}\right)}$

(c) $\omega = \sqrt{\frac{g}{R}\left(\frac{\mu_s \sin\varphi}{\mu_s \sin^2\varphi + \cos^2\varphi \sin\varphi}\right)}$

(d) $\omega = \sqrt{\frac{g}{R}\left(\frac{\cos\varphi}{\mu_s \sin^2\varphi}\right)}$

(e) $\omega = \sqrt{\frac{g}{R}\left(\frac{\mu_s \cos\varphi - \sin\varphi}{\mu_s \sin^2\varphi + \cos\varphi \sin\varphi}\right)}$

Group Number		Name		Type
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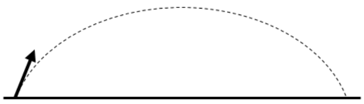
1. Which force is responsible for holding a car in the track, in an unbanked curve?
(a) The car's weight
(b) The car's engine force
(c) The kinetic friction force
(d) The static friction force
(e) The normal force

2. Which statement is always true for an object having constant $|\vec{v}|$?
(a) $a_{\rm rad} = 0$ (b) $|a_{\rm tan}| \geq |a_{\rm rad}|$ (c) $|a_{\rm tan}| > |a_{\rm rad}|$ (d) $|\vec{a}| = 0$ (e) $a_{\rm tan} = 0$

3. Bodies A and B are thrown from the same position with the same initial speeds at angles $\alpha_{\rm A}$ and $\alpha_{\rm B}$. Both bodies hit to the same point on the ground. Which of the following is always correct?
(a) $\alpha_{\rm A} + \alpha_{\rm B} = \pi/2$
(b) $\alpha_{\rm A} + \alpha_{\rm B} = \pi$
(c) $\alpha_{\rm A} - \alpha_{\rm B} = \pi/2$
(d) $\sqrt{\alpha_{\rm A}^2 + \alpha_{\rm B}^2} = \pi/2$
(e) $\alpha_{\rm A} + \alpha_{\rm B} = \pi/4$

4. If the weight of an object of mass 10 kg is 50 N, then what is the maximum range of the object thrown with an initial speed of 50 m/s? (Assume that there is no air resistance.)



(a) 5 m (b) 500 m (c) 250 m (d) 10 m (e) 1000 m

Questions 5-6

One of the forces acting on a particle with a mass of 1 kg is given as $\vec{F}(t) = 3t\,\hat{\imath} - 2\,\hat{\jmath}$ [Newton] and its position is given as $\vec{r}(t) = t/2\,\hat{\imath} - t^3\,\hat{\jmath}$ [meter]

5. What is the average velocity in m/s between $t = 1$ and $t = 3$ sec?
(a) $1/2\,\hat{\imath} - 3\,\hat{\jmath}$ (b) $2\,\hat{\imath} - 12\,\hat{\jmath}$ (c) $2\,\hat{\imath} + 14\,\hat{\jmath}$ (d) $1/2\,\hat{\imath} - 14\,\hat{\jmath}$ (e) $1/2\,\hat{\imath} - 13\,\hat{\jmath}$

6. What is the instantaneous power acting on this particle by the forces other than $\vec{F}$ at $t = 2$ sec?
(a) -123 W (b) 117 W (c) -120 W (d) 123 W (e) 67 W

Questions 7-9

The velocity of a particle moving in a straight line is given as $v(t) = (-t^2/2 + 3t + 3/2)$ where t is in seconds and v is in m/s.

7. Calculate the particle's acceleration at $t = 2$ s.
(a) 3 m/s^2 (b) 5 m/s^2 (c) 11/2 m/s^2 (d) 1 m/s^2 (e) 4 m/s^2

8. Compute the time when the force acting on the particle changes its direction.
(a) 19/2 s (b) 3/2 s (c) 0 s (d) 1 s (e) 3 s

9. Calculate the position r of the particle when the force acting on the particle changes its direction. Take $r(t = 0) = 0$.
(a) 27/2 m (b) 0 (c) 23/3 m (d) 17/6 m (e) 27/5 m

Questions 10-14

Position vector of an object A with mass m_{A} relative to the Earth (E) is given as $\vec{r}_{\text{A/E}} = (3t^2 + 104)\hat{\imath} + 2t\hat{\jmath} + \hat{k}$, that of object B with mass $m_{\text{B}} =$ relative to the object A is given as $\vec{r}_{\text{B/A}} = (-t^2 + 2t - 100)\hat{\imath} + (-2t + 5)\hat{\jmath} - \hat{k}$. ($m_{\text{A}} = 10$ kg, $m_{\text{B}} = 5$ kg)

10. Find the position vector of B relative to the Earth, $\vec{r}_{\text{B/E}}$.
(a) $(4t^2 - 2t + 204)\hat{\imath} + (4t - 5)\hat{\jmath} + 2\hat{k}$
(b) $(-2t^2 - 2t - 4)\hat{\imath} - 5\hat{\jmath}$
(c) $(2t^2 + 2t + 4)\hat{\imath} + 5\hat{\jmath} + 2\hat{k}$
(d) $(-4t^2 + 2t - 204)\hat{\imath} + (-4t + 5)\hat{\jmath} + 2\hat{k}$
(e) $(2t^2 + 2t + 4)\hat{\imath} + 5\hat{\jmath}$

11. Find the velocity of B relative to the Earth, $\vec{v}_{\text{B/E}}$.
(a) $(8t - 2)\hat{\imath} + 4\hat{\jmath}$ (b) $(-4t - 2)\hat{\jmath}$ (c) $(4t + 2)\hat{\imath}$ (d) $(-8t + 2)\hat{\imath} - 4\hat{\jmath}$ (e) $(-4t - 2)\hat{\imath}$

12. Find the magnitude of the total external force exerted on B.
(a) 20 N (b) $(20t + 10)$ N (c) 40 N (d) 0 N (e) -20 N

13. Find the speed of A relative to B at $t = 0$.
(a) 2 m/s (b) $2\sqrt{2}$ m/s (c) 4 m/s (d) $2\sqrt{5}$ m/s (e) 0 m/s

14. When do A and B meet each other? (Assume they are point particles)
(a) $t = \sqrt{11}$ s (b) $t = 101$ s (c) $t = 5/2$ s (d) Never (e) $t = 5/4$ s

Questions 15-17

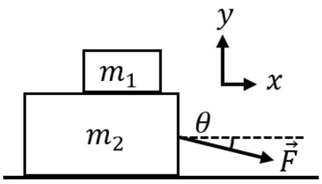
A luggage handler pulls a 20 kg suitcase up a ramp inclined θ above the horizontal by a force of magnitude 210 N, parallel to the ramp. The coefficient of kinetic friction between the ramp and the incline is $\mu_k = 3/8$.
($\sin(\theta) = 3/5$, $\cos(\theta) = 4/5$, $g = 10$ m/s^2)
If the suitcase takes 3 m distance along the ramp;

15. Calculate the work done on the suitcase by the gravitational force
(a) -180 J (b) 0 (c) 360 J (d) -360 J (e) -135 J

16. Calculate the total work done on the suitcase.
(a) 90 J (b) 480 J (c) 0 (d) 360 J (e) 300 J

17. If the speed of the suitcase is zero at the bottom of the ramp, what is the speed when it takes 3m along the ramp?
(a) $4\sqrt{2}$ m/s (b) 3 m/s (c) 0 (d) $2\sqrt{6}$ m/s (e) $\sqrt{6}$ m/s

Questions 18-20



A block of mass m_1 rests on top of another block of mass m_2, which rests on a frictionless horizontal surface. The coefficient of static and kinetic friction between the two blocks are $\mu_s = 1/2$ and $\mu_k = 1/4$, respectively. A force F is applied to m_2 as shown in figure. ($m_1 = 1$ kg, $m_2 = 2$ kg, $\sin(\theta) = 4/5$, $\cos(\theta) = 3/5$, $\vec{g} = -10$ m/s^2 $\hat{\jmath}$)

18. Which magnitude of $\vec{F}$ below ensures that the blocks accelerate together without m_1 sliding on m_2?
(a) 32 N (b) 29 N (c) 22 N (d) 26 N (e) 34 N

19. Find the acceleration of each block for $F = 15$ N.
(a) $7/2$ m/s^2 (b) 5 m/s^2 (c) 3 m/s^2 (d) 2 m/s^2 (e) $9/2$ m/s^2

20. Find the acceleration of each block for $F = 35$ N, where a_1 is the aceleration of m_1 and a_2 is the aceleration of m_2, relative to the horizontal surface.
(a) $a_1 = 5$ m/s^2, $a_2 = 8$ m/s^2
(b) $a_1 = 5/2$ m/s^2, $a_2 = 21$ m/s^2
(c) $a_1 = 5/2$ m/s^2, $a_2 = 37/4$ m/s^2
(d) $a_1 = 2$ m/s^2, $a_2 = 51/4$ m/s^2
(e) $a_1 = 1/2$ m/s^2, $a_2 = 21$ m/s^2

Group Number		Name		Type
List Number		Surname		A
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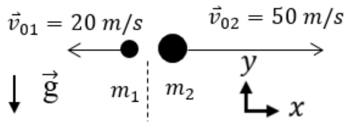
1. The fluid resistance acting on a mass m released into a liquid is given as $F = kv$ in Newtons where k is a constant, v is the velocity of the object. The buoyant force acting on this object is given as $f = A\rho g$, where A is the volume of the object, g is the gravitational acceleration and ρ is the density of the liquid. Accordingly, which of the following equations is an expression obtained from Newton's 2nd law? (buoyant force: [TR] kaldırma kuvveti)

(a) $\frac{d^2x}{dt^2} = \frac{k}{m}\frac{dx}{dt} + g\left(1 + \frac{\rho A}{m}\right)$
(b) $\frac{d^2x}{dt^2} = \frac{k}{m}\frac{dx}{dt} - g\left(1 - \frac{\rho A}{m}\right)$
(c) $\frac{d^2x}{dt^2} = -\frac{k}{m}\frac{dx}{dt} + g\left(1 + \frac{\rho A}{m}\right)$
(d) $\frac{d^2x}{dt^2} = -\frac{k}{m}\frac{dx}{dt} + g\left(1 - \frac{\rho A}{m}\right)$
(e) $\frac{d^2x}{dt^2} = -\frac{k}{m}\frac{dx}{dt} - g\left(1 - \frac{\rho A}{m}\right)$

Questions 2-5

As shown in the figure, the masses m_1 and m_2 are thrown from a high location, parallel to the ground and in opposite directions, at speeds of $v_{01} = 20$ m/s and $v_{02} = 50$ m/s. Neglect the air friction and take $g = 10$ m/s^2.



2. In which of the following option are the velocities of the masses at $t = 3$ s correctly given?

(a) $\vec{v}_1 = 20\hat{\imath} - 30\hat{\jmath}$; $\vec{v}_2 = 40\hat{\imath} - 30\hat{\jmath}$ (b) $\vec{v}_1 = -20\hat{\imath} - 30\hat{\jmath}$; $\vec{v}_2 = 50\hat{\imath} - 30\hat{\jmath}$ (c) $\vec{v}_1 = -10\hat{\imath} - 30\hat{\jmath}$; $\vec{v}_2 = 30\hat{\imath} - 30\hat{\jmath}$
(d) $\vec{v}_1 = -20\hat{\imath} - 30\hat{\jmath}$; $\vec{v}_2 = -30\hat{\imath} - 30\hat{\jmath}$ (e) $\vec{v}_1 = 10\hat{\imath} - 30\hat{\jmath}$; $\vec{v}_2 = 30\hat{\imath} - 30\hat{\jmath}$

3. What is the distance between the masses in unit of meters at $t = 3\ s$?

(a) 150 (b) 250 (c) 180 (d) 210 (e) 230

4. What is the velocity of mass m_1 with respect to mass m_2 at $t = 3\ s$?

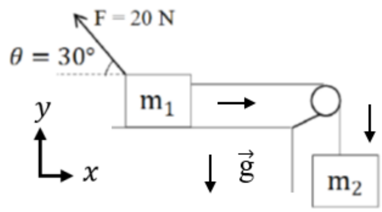
(a) $-80\hat{\imath}$ m/s (b) $-60\hat{\imath}$ m/s (c) $80\hat{\imath}$ m/s (d) $-70\hat{\imath}$ m/s (e) $75\hat{\imath}$ m/s

5. At which instant t are the velocities of masses perpendicular to each other?

(a) $\sqrt{7}$ s (b) 4 s (c) $\sqrt{12}$ s (d) 3 s (e) $\sqrt{10}$ s

Questions 6-9

Two masses $m_1 = 2.0$ kg and $m_2 = 3.0$ kg are connected by a massless string passing over a massless and frictionless pulley. Mass m_1 moves on a horizontal surface having a coefficient of kinetic friction $\mu_k = 0.50$ and is subject to a force $F = 20.0$ N. ($\cos 30° = 0.9,\ \sin 30° = 0.5,\ g = 10$ m/s^2)



6. What is the magnitude of the acceleration of m_2?
(a) 0.7 m/s^2 (b) 1.4 m/s^2 (c) 2.4 m/s^2 (d) 0.8 m/s^2 (e) 1.8 m/s^2

7. What is the tension on the string?
(a) 25.8 N (b) 15.6 N (c) 20.0 N (d) 21.4 N (e) 18.0 N

8. What is the magnitude of the frictional force on m_1?
(a) 4.0 N (b) 7.0 N (c) 5.0 N (d) 3.0 N (e) 8.0 N

9. What should be the mass m_1 if the two masses move with a constant speed?
(a) 2.6 kg (b) 4.0 kg (c) 3.4 kg (d) 1.8 kg (e) 2.0 kg

Questions 10-11

A small block of mass $m = 0.5$ kg sits 2.25 m from the center of a horizontal turntable whose frequency of rotation is f and the coefficient of static friction between the block and the turntable is $\mu_s = 0.9$. Take $g = 10$ m/s^2, $\pi \approx 3$.

10. What is the maximum value of f to keep the block at rest with respect to the turntable?
(a) $\frac{2}{3}$ Hz (b) $\frac{1}{5}$ Hz (c) 2.0 Hz (d) $\frac{1}{3}$ Hz (e) 1.0 Hz

11. If $f = 0.25$ Hz, what is the magnitude of the friction?
(a) $\frac{93}{17}$ N (b) $\frac{81}{32}$ N (c) $\frac{76}{35}$ N (d) $\frac{49}{14}$ N (e) $\frac{41}{17}$ N

Questions 12-13

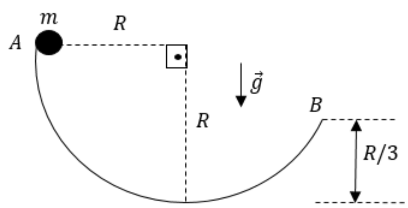
A small puck of mass $m = 0.3$ kg moves in a circle of radius $R = 1.5$ m on a table; the puck is tied with a massless string to a pin at the center of the circular path. The coefficient of kinetic friction between the puck and the table is $\mu_k = 0.2$. At $t = 0$, the puck starts rotating with an initial speed $v_0 = 10$ m/s. Take $g = 10$ m/s^2, $\pi \approx 3$.

12. What is the tension in the string at $t = 0$?
(a) 20 N (b) 10 N (c) 15 N (d) 30 N (e) 25 N

13. What is the tension in the string at the end of one revolution?
(a) 14.6 N (b) 10.6 N (c) 12.8 N (d) 11.0 N (e) 15.2 N

Questions 14-15

A block of mass m slides on a frictionless loop-to-loop track of radius R, as shown in the figure. The block starts from rest at point A.



14. What is the speed of the block at point B?
(a) $\sqrt{\frac{5gR}{2}}$ (b) $\sqrt{\frac{4gR}{3}}$ (c) $\sqrt{\frac{3gR}{5}}$ (d) $\sqrt{\frac{7gR}{3}}$ (e) $\sqrt{\frac{8gR}{5}}$

15. What is the magnitude of the normal force at point B?
(a) $1.5mg$ (b) $2.5mg$ (c) $2mg$ (d) mg (e) $3mg$

Questions 16-17

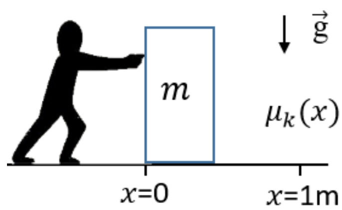
A net force $\vec{F} = (4x - 3x^2)\hat{i}$ acts on a particle as the particle of mass m moves along the x-axis, with $\vec{F}$ in newtons, x in meters.

16. What is the work done by the net force in moving the particle from the origin $x = 0$ to $x = 3$ m?
(a) -7 J (b) 6 J (c) 8 J (d) -8 J (e) -9 J

17. At $x = 0$ the particle's speed is $\sqrt{10}$ m/s, at $x = 3$ m, its kinetic energy is 11 J. Find the mass of the particle.
(a) 4 kg (b) 2 kg (c) 5 kg (d) 3 kg (e) 6 kg

Questions 18-20

A worker pushes a 20-kg crate straight across a 1-m-long section of horizontal floor with a constant force of $F = 20$ N. This section of the floor has the peculiarity that it becomes rougher from beginning to end, and the crate is moving at 2 m/s when it arrives at the start of this section. The coefficient of friction is 0.15 at the start and 0.25 at the finish, varying linearly with distance in between. ($g = 10$ m/s^2)



18. What is the coefficient of kinetic friction as a function of distance x?
(a) $\mu_k(x) = 0.15 + 0.10x$ (b) $\mu_k(x) = 0.15 + 0.25x$ (c) $\mu_k(x) = 0.15 + 0.15x$
(d) $\mu_k(x) = 0.20 + 0.10x$ (e) $\mu_k(x) = 0.10 + 0.25x$

19. What is the work done by the net force acting on the block?
(a) -17 J (b) 25 J (c) 17 J (d) -15 J (e) -20 J

20. What is the speed of the crate at the end of the section?
(a) $\sqrt{5}$ m/s (b) $\sqrt{3}$ m/s (c) 2 m/s (d) 3 m/s (e) $\sqrt{2}$ m/s

Group Number		Name		Type
List Number		Surname		A
Student ID		Signature		
e-mail				

ATTENTION: There is normally only one correct answer for each question and each correct answer is equal to 1 point. Only the answers on your answer sheet form will be evaluated. Please be sure that you have marked all of your answers on the answer sheet form by using a pencil (*not* pen).

Questions 1-2

Two vectors $\vec{A} = 2\hat{\imath} - a\hat{\jmath} + \hat{k}$ and $\vec{B} = 3\hat{\imath} + \hat{\jmath} - 2\hat{k}$ are given. If $\vec{A} \cdot \vec{B} = 3$,

1. What is a?
(a) -1 (b) 1 (c) -2 (d) $-1/3$ (e) 2

2. What is the unit vector in the direction of $\vec{A} + \vec{B}$?
(a) $(-5\hat{\imath}+\hat{k})/\sqrt{26}$ (b) $(\hat{\imath}+\hat{\jmath}+\hat{k})/\sqrt{41}$ (c) $(5\hat{\imath}-\hat{k})/\sqrt{26}$ (d) $(\hat{\imath}+2\hat{\jmath}-\hat{k})/\sqrt{14}$ (e) $(-\hat{\imath}-2\hat{\jmath}+\hat{k})/\sqrt{14}$

Questions 3-5

An object with mass of 0.5 kg has a non-constant acceleration, given by $a(t) = 3\left(\frac{\text{m}}{\text{s}^4}\right)t^2 - 1\left(\frac{\text{m}}{\text{s}^2}\right)$ where t is measured in seconds.

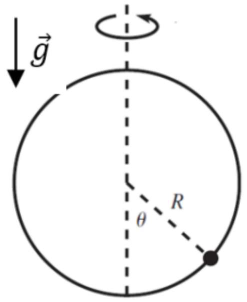
3. What is the amount of displacement the object made in 2 seconds if its initial velocity $v(t{=}0)$ is 3 m/s?
(a) 8 m (b) 9 m (c) 6 m (d) 12 m (e) 24 m

4. What is the average force applied to the object in this time interval: from 0 s to 2 s?
(a) 5 N (b) 1.5 N (c) 3 N (d) 6 N (e) 2.5 N

5. What is the acceleration of the object when its velocity is 9 m/s?
(a) 26 m/s^2 (b) 11 m/s^2 (c) 28 m/s^2 (d) 13 m/s^2 (e) 9 m/s^2

Questions 6-8

A bead of mass m is free to move around the frictionless wire hoop with radius R which is spinning at a fixed rate about its vertical axis. If the bead maintains the same position with respect to the hoop, at a constant angle θ with respect to the vertical, as shown in the figure, while it is making a uniform circular motion as the hoop spins



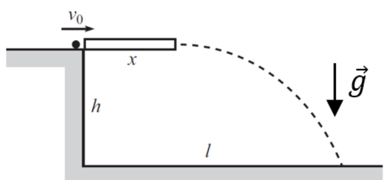
6. What is the vertical component of the normal force on the bead applied by the hoop?
(a) $mg\cot\theta$ (b) $mg\cos\theta$ (c) $mg\tan\theta$ (d) $mg\sin\theta$ (e) mg

7. What is the horizontal component of the normal force on the bead applied by the hoop?
(a) $mg\cos\theta$ (b) mg (c) $mg\sin\theta$ (d) $mg\tan\theta$ (e) $mg\cot\theta$

8. What is the speed squared: v^2 of the bead?
(a) $gR\tan\theta\sin\theta$ (b) $gR\cos\theta\sin\theta$ (c) $gR\cot\theta\sin\theta$ (d) $gR\cot\theta\cos\theta$ (e) $gR\tan\theta\cos\theta$

Questions 9-12

A particle is thrown horizontally with an initial speed v_0 from the top edge of a wall of height h. As soon as it is thrown, the particle enters a fixed tube with length x, as shown in the figure. There is friction between the particle and the tube; therefore the particle decelerates with constant acceleration $-a$ (where $a > 0$) inside the tube. After the particle exits the tube, it makes the usual projectile motion down to the ground.



9. What is the total horizontal distance l (measured from the edge of the wall) that the particle travels?
(a) $x+\sqrt{v_0^2-2ax}\sqrt{\frac{h}{g}}$ (b) $x+\sqrt{v_0^2-ax}\sqrt{\frac{2h}{g}}$ (c) $x+\sqrt{v_0^2-ax}\sqrt{\frac{h}{g}}$ (d) $x+\sqrt{v_0^2-2ax}\sqrt{\frac{2h}{g}}$
(e) $x+\sqrt{v_0^2-2ax}\sqrt{\frac{h}{2g}}$

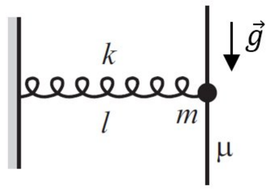
10. What is the length x of the tube which yields maximum l?
(a) $\frac{v_0^2}{2a}-\frac{ah}{2g}$ (b) $\frac{v_0^2}{2a}-\frac{ah}{g}$ (c) $\frac{v_0^2}{a}-\frac{ah}{4g}$ (d) $\frac{v_0^2}{2a}-\frac{ah}{4g}$ (e) $\frac{v_0^2}{a}-\frac{ah}{2g}$

11. What is the horizontal component of the velocity when the particle hits the ground?
(a) $\sqrt{v_0^2-ax}$ (b) $\sqrt{v_0^2-ah}$ (c) $\sqrt{v_0^2-2ah}$ (d) $\sqrt{v_0^2-4ax}$ (e) $\sqrt{v_0^2-2ax}$

12. What is the vertical component of the velocity when the particle hits the ground?
(a) $-\sqrt{2gh}$ (b) $-\sqrt{gx}$ (c) $-\sqrt{2gx}$ (d) $-\sqrt{4gh}$ (e) $-\sqrt{gh}$

Questions 13-17

One end of a spring with spring constant k and relaxed length zero is attached to a wall and the other end is attached to a ring with mass m which can move on a verticle rod of infinite length. The rod is fixed at a distance l from the wall as shown in the figure. The friction coefficient between the ring and the rod is μ (both static and kinetic). The ring is held such that the spring is horizontal as shown in the figure and then released.



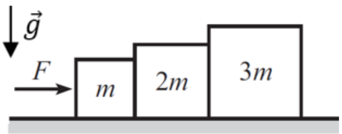
13. What is the normal force between the ring and the rod?
(a) $\sqrt{2}kl$ (b) $\sqrt{3}kl/2$ (c) $2kl$ (d) kl (e) $kl/2$

14. How far does the ring fall down on the rod before starting to move back up?
(a) $2(\frac{mg}{k}-\sqrt{2}\mu l)$ (b) $\frac{mg}{k}-\mu l$ (c) $\frac{mg}{k}-2\mu l$ (d) $2(\frac{mg}{k}-\mu l)$ (e) $2(\frac{mg}{k}-2\mu l)$

15. What is the maximum value of μ so that the ring can fall when it is released?
(a) $\frac{mg}{2kl}$ (b) $\frac{2mg}{kl}$ (c) $\frac{2mg}{3kl}$ (d) $\frac{mg}{kl}$ (e) $\frac{mg}{\sqrt{2}kl}$

16. What is the maximum value of μ so that the ring can move back up when it reaches the lowest possible position in its motion?
(a) $\frac{mg}{6kl}$ (b) $\frac{mg}{kl}$ (c) $\frac{mg}{\sqrt{2}kl}$ (d) $\frac{mg}{3kl}$ (e) $\frac{mg}{2kl}$

17. Three blocks of masses m, $2m$ and $3m$ are pushed by a force F across a frictionless horizontal surface as shown in the figure. If the normal force between the left two blocks is N_1 and the normal force between the right two blocks is N_2, what are N_1 and N_2 in terms of m and acceleration a?



(a) N_1=5ma , N_2=3ma (b) N_1=3ma , N_2=ma (c) N_1=4ma , N_2=2ma (d) N_1=6ma , N_2=6ma
(e) N_1=6ma , N_2=4ma

Questions 18-20

As part of your gym training, you lie on your back and push with your feet against a platform attached to two identical stiff springs arranged side by side so that they are parallel to each other. When you push the platform, you compress the springs. You do 80 J of work when you compress the springs 0.2 m from their uncompressed length.

18. What is the value of each spring constant?
(a) 4000 N/m (b) 500 N/m (c) 200N/m (d) 1000 N/m (e) 2000 N/m

19. What magnitude of force must you apply to hold the platform in this compressed position?
(a) 1600 N (b) 200 N (c) 800 N (d) 600 N (e) 400 N

20. How much additional work must you do to move the platform 0.200 m farther from the compressed position, and what maximum force must you apply?
(a) 240 J, 400 N (b) 240 J, 1600 N (c) 240 J, 800 N (d) 180 J, 1000 N (e) 180 J, 1600 N